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Discourse into Action: Gender Issues Reflected in Alberta's Physics Curriculum Revision (1984-1995)

by

Elisa Rawe

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of **Master of Education**

Department of Secondary Educaton

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Faculty of Graduate Studies and Research

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Dr. Peter Wright

Date: July 25, 2003

Abstract

In this historical case study, the documents that supported the 1984-1995 revision of the Physics 20-30 program of studies in Alberta were analyzed and semi-structured interviews with four key actors in the revision process were conducted. A moderate amount of discourse on issues related to gender differences in physics participation and a small amount of discourse on gender differences in physics achievement occurred during the revision process. At least partially in response to these issues, a chapter on "Teaching with a Gender Balance" was included in the High School Science Teachers Manual; STS examples in the Physics 20-30 Program of Studies were scrutinized for gender friendly context and a general integrated grade 10 science course was developed. One action that was not taken was to include female scientists in the program of studies document. Some conditions that might have supported the translation of discourse into action are described.

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List of Abbreviations

CAC	Curriculum Advisory Committee
CMEC	Council of Ministers of Education
IAEP	International Assessment of Educational Progress II
SAIP	School Achievement Indicators Program
SISS	Second International Science Study
STS	Science, Technology and Society
TIMMS	Third International Mathematics and Science Study
WISEST	Women in Scholarship, Engineering, Science and Technology

Locating the Research: Gender Issues and Curriculum Action

Introduction

The persistence of gender differences in achievement in high school physics as measured by large scale international assessments and the persistence of a large gender difference in participation in high school physics courses in Alberta concern me. In this research I investigate the historical evidence related to one possible action that could have been taken to respond to these issues in Alberta - science curriculum revision.

Persistence of an Issue

Why are there still large gender differences in achievement in science on some large scale assessments? The Third International Mathematics and Science Study (TIMSS) administered in 1995-96, is a multi-year, large scale assessment given to representative samples of three different school aged populations in more than forty countries. Not only was the achievement of girls lower on the TIMSS science literacy assessment, it was significantly lower as well in the TIMSS physics assessment for students in the final year of high school – a subject in which the girls' participation rate was also low (Robitaille Taylor, Orpwood & Donn, 1998). For example, in Alberta of the students who chose to study physics in grade 12 during the 1998/99 school year, 36.8% were female and 63.2% were male (Alberta Learning, 2000). This difference in participation rate by gender is echoed world-wide in many countries. Why were girls avoiding physics and when they did participate why were they achieving less well on average than boys, at least as measured by these assessments?

Over the last few years these questions have troubled me. When I was a young woman exploring a career in research science I felt somewhat alone among my female friends in my choices. I was even "alone" in some of my classes – including physics. But research on gender differences in science achievement and participation has been extensive since that time. I didn't expect gender differences in science achievement or participation to still be an issue during my own daughters' young adulthood. I didn't expect it to still be an issue twenty years later, when I was teaching science to high school students. I was optimistic that concern about the issues would translate into actions, and

differences would disappear. However, it still seemed to be an issue.

I'm not alone in my concerns nor is my perception of the persistence of these issues unique. The following sources illustrate the persistence of the issue in Canada over a period of 18 years:

In the overview of a major report by the Science Council of Canada (1984) *Science for Every Student: Educating Canadians for Tomorrow's World* it states:

> The major findings of the study concern the serious gap between what science education is *supposed* to achieve and what it *actually* achieves. For example:
>
> - Many girls still do not see scientific or technological careers as being relevant to them, and turn away from science; both Canada and half of its citizens are the losers. [one of six bulleted points] (p. 10)

Science Education in Canada: Achievement and its Correlates (Connelly, Crocker & Kass, 1985a) is part of a two volume report on a two-year study of science education in Canada that looked at curriculum reform, national and local Canadian concerns and student achievement as measured by the Second International Science Study (SISS). In one section of the report gender differences in achievement and survey data from the SISS were analyzed. In the summary the authors state that:

> Canadian students are generally positive about the importance of science, the science taught in their schools, and possible careers in science.... Although a few regional differences in attitudes were seen, these seemed minor in relation to the consistent gender differences observed. Across grades, boys like science more and receive better grades in it than girls. As they grow older, boys begin to express greater liking of the science taught in schools and are more attracted to careers in science. (pp. 214-215)

In a publication by the Canadian Teachers' Federation (Robertson, 1988) titled *The IDEA Book: A Resource for Improving the Participation and Success of Female Students in Math, Science and Technology* the author states in the problem definition section that:

> Girls appear to be less successful in the sciences and their participation rates in these courses decline as they progress through the grades; many girls do not see technology or science as being relevant or appropriate for them, either as classroom subjects or as the basis for future education employment. (p.4)

In the document *Setting the Stage for the Next Century: The Federal Plan for Gender*

Equality (Status of Women Canada, 1995) item 82 states in part:

> Women are still under-represented in many non-traditional occupations; emerging occupational categories are quickly dominated by men. As of 1993, women represented ... just 18 percent of managers in the fields of natural sciences, engineering and mathematics. (p. 27)

In the reported proceedings of the Alberta Science Education Leaders' Symposia on December 5, 1997 in Calgary and March 13, 1998 in Edmonton (Alberta Education, 1998a) the following general concern about the current secondary science programs was expressed: "There is a continuing need to attract and retain more female students in science programs" (p. 6).

On a web-site for the Chair for Women in Science and Engineering at the University of Calgary (2002) are posted papers relating to a large multi-study project to study "the key influences on junior and senior high school students' choices for various activities, courses and careers, particularly in the sciences" (p.1). In one of these papers the following rationale for the project is stated:

> Knowledge of mathematics and the sciences is an essential prerequisite in the pursuit of high-status and well-paid jobs in a technologically advanced workforce. ... recent data reveal that graduate enrollments in the natural sciences and engineering have been leveling off in terms of studies of post-secondary program selection, and adult career choice, along with a significant under-representation of females in fields like engineering. (Lupart and Cannon, 2000. p.1-2)

These quotes are not meant to insinuate that these are issues for everyone – merely that they exist. Talk about the issues of gender differences in science participation and achievement were persisting over time. I began to wonder whether action had been taken on the issues and had been unsuccessful, change was occurring slowly but concerns still existed, or whether talk was replacing actions.

Alberta's Data Related to the Issue

From 1997 to 2001 I worked at Alberta Education in Learner Assessment. (Alberta Education has been renamed Alberta Learning. For the purpose of this study it will be referred to throughout as Alberta Education.) Data on achievement on provincial high school diploma examinations and on large-scale assessments like TIMSS were

discussed formally and informally. Participation rates in science were also discussed. Gender differences in these measures were part of that discussion. What does data on participation and achievement in science by gender in Alberta reveal about trends in these differences?

International tests of physics achievement show a persistence of gender differences in achievement. Data from SISS, conducted in 1984, indicates that on the physics items of the general science test for grades 12 and 13, there was a significant difference between male and female mean scores of 3.1 % in favor of the males (46.5% males and 43.4 % females). There was also a significant gender difference on the specialized physics test for grades 12/13 of 5.8 % in favour of males (Connelly, Crocker & Kass, 1985a). Data from TIMSS, conducted in 1995, indicates that , for Alberta, the difference between the male and female mean scores on the grade 12 physics portion of this assessment was 4.7 ($p = 0.05$) in favor of the males, the same as the Canadian sample overall. (Robitaille et. al., 1998). In contrast to these results, provincial assessments of grade 12 physics in Alberta show little gender differences in achievement. Figure 1 illustrates this starting in the school year 1989-1990; the first year gender statistics on achievement for the year were available. This data was obtained from the *Annual Report: Diploma Examinations Program* for consecutive school years from 1989-1990 through 1999-2000 (Alberta Education, 1991b, 1992d, 1993c, 1994b, 1995b, 1996, 1997, 1998b, 1999 and Alberta Learning, 2000)

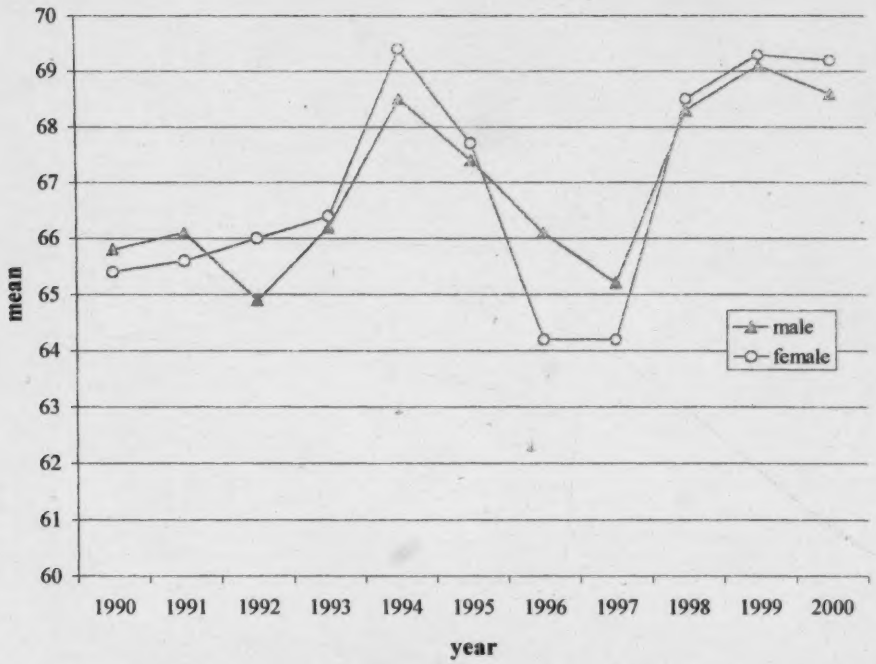


Figure 1. Mean yearly achievement by gender on Physics 30 diploma examinations

Gender differences in high school physics achievement in Alberta seem relatively small. What about gender differences in high school physics participation? Figure 2 and Figure 3 indicate the trends in participation in grade 12 physics (Physics 30), in Alberta. Figure 2 is based on enrollment in Physics 30 as reported in the *Annual Report: Alberta Education* for the school years 1980-1981 through 1993-1994 (Alberta Education, 1982, 1983, 1984a, 1985a, 1986, 1987a, 1988, 1989, 1990a, 1991a, 1992c, 1993b, 1994a, 1995a). This data was no longer included in the report after the 1993-1994 school year. Figure 3 is based on completion of Physics 30 (diploma and course mark) as reported in the *Annual Report: Diploma Examination Program* for the school years 1989-1990 through 1999-2000 (Alberta Education, 1991b, 1992d, 1993c, 1994b, 1995b, 1996, 1997, 1998b, 1999 and Alberta Learning, 2000).

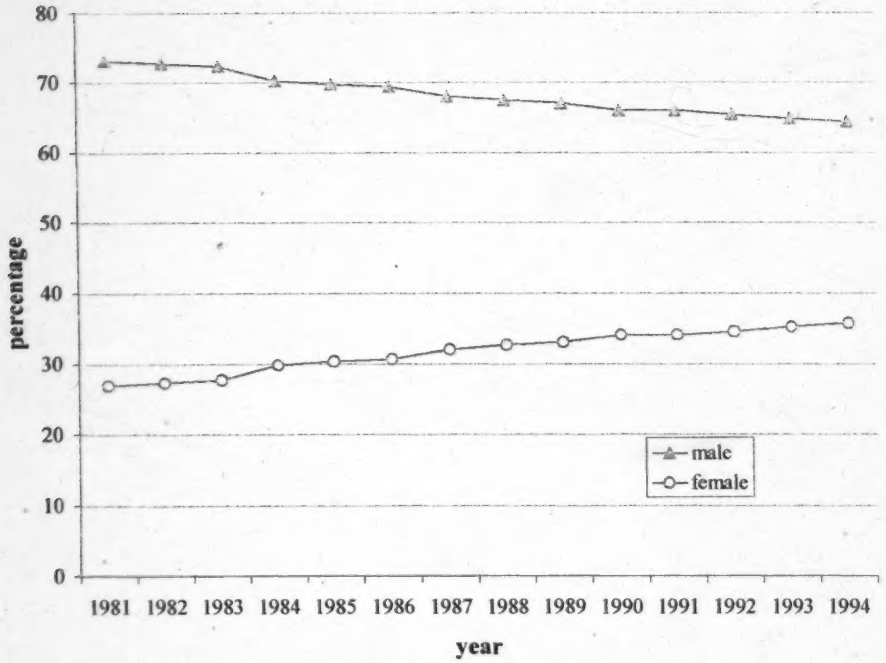


Figure 2. Enrollment by gender in Physics 30 in Alberta

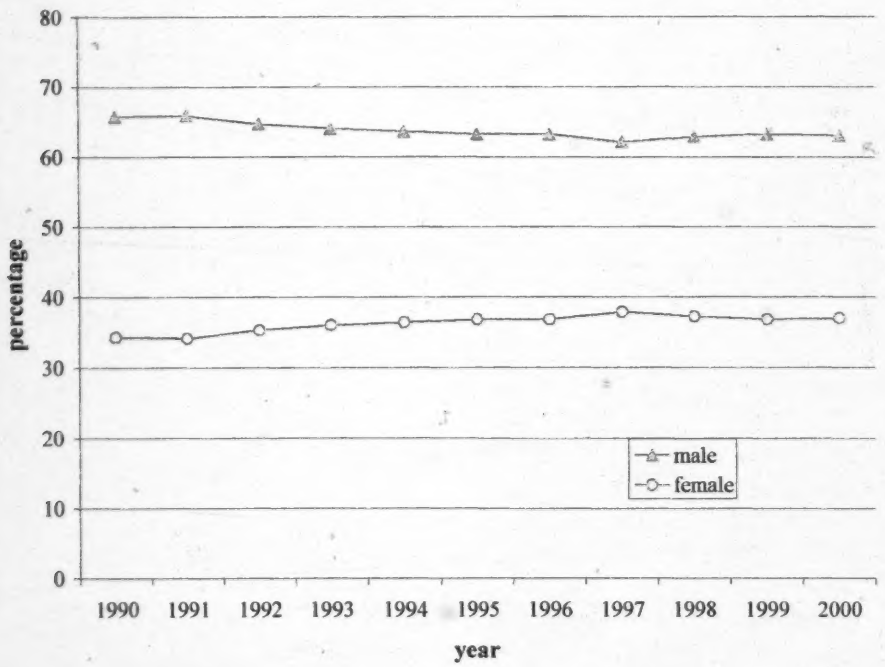


Figure 3. Completion of Physics 30 course by gender in Alberta

Figure 2 and Figure 3 indicate that although there have been some changes in participation by gender in physics in Alberta there has been very little change since 1994.

Refining the Issue – Why are the Differences a Concern?

Gender differences in participation in physics are more clearly persistent in Alberta than achievement differences. Although gender differences in achievement in physics in Alberta are less clearly a persistent trend, small differences in achievement on international tests have persisted. Achievement differences in physics achievement may also be linked to the relatively low participation of females in high school physics courses. This will be discussed in Chapter 2 (The Background) in more detail.

Concern about the relatively low participation of females in many science-related careers falls into three main categories:

1. Economic reasons: Increasing women's participation in the sciences would solve some labour shortage problems, more of the talent pool would be accessed and participation would increase an individual woman's earning power (Alberta Education, 1992e; Bellamy & Guppy, 1991; Lupart & Canon, 2001; Rosser, 1993; Status of Women Canada, 1995; Robertson, 1988).

2. Power reasons: Increasing women's participation in the sciences would increase their access to decision-making in a critical area (Ferguson, 1982; Robertson, 1988; Science Council of Canada, 1982, 1984; Smith, 1991).

3. Transformation reasons: Increasing women's participation in the sciences would change the nature of these sciences in a positive way for society (Harding, 1986; Keller, 1983; McIntosh, 1984; Osborne and Barton, 2000; Rosser, 1993; Spanier, 1984).

In contrast to my own continued concern, and the concerns expressed in many other documents about gendered participation trends in physics, many educators in Alberta that I spoke to felt that this was no longer an issue of importance to them. To paraphrase these conversations, it was expressed as "been there, done that, time to move on". Why did it appear that many educators felt enough had been done? They may have felt that actions on gender issues in science had been taken in Alberta. They may also have felt that these actions were sufficient. One piece of the answer to this puzzle would

be to investigate actions taken in Alberta in response to gender issues in the past. One possible location for action is the physics curriculum.

One Site of Possible Action – Curriculum Revision

As I read research, papers and books related to feminist theories and gender differences in science achievement and participation – one of the themes that seemed to emerge for me was the role of the science curriculum in influencing gender differences in science participation. Science as a subject area has a particular curricular knowledge base. Feminists such as Harding (1986), Keller (1983) and Lather (1991) critique the nature of science and the method of "knowing" that it implies as "masculine" in nature based on social concepts of what is "male" and "female". They theorize that this masculine science discourages participation of many females (and some males) in courses and careers related to the physical sciences.

Curriculum can be thought of as all aspects of the classroom environment that a student experiences, including the intended and unintended curriculum. The masculine nature of science, according to some feminist theorists, is one possible example of an unintended curriculum that students experience in relation to the physics curriculum. The extent to which the intended curriculum is directly mandated to educators by policy makers can range from general statements that describe the goals of education to tightly administered proscribed teaching units that included methods, materials and content that teachers must cover (Miller, 2000). In Alberta, as described further in Chapter 4 (The Context), the *Physics 20-30 Program of Studies* influences classrooms as a legal document for teachers, a guide to resource selection and the basis of the high stakes diploma examination program which likely influences what aspects of the written curriculum are attended to. Therefore action on gender issues through Alberta's high school physics curricula is possible.

Written curricula are produced in a context of historical forces which influence the policies of education authorities. One of these forces in Canada has been the influence of feminists on government policy. Different feminist view points are illustrated in the history of concern in Canada about unequal gender participation and achievement in science (Gaskell, 1993). The types of policy changes, including curricula changes,

advocated by these perspectives are different. At a particular time in Alberta's history, these historical perspectives may be reflected in the discourse on gender issues and the actions taken within the high school physics curricula in Alberta.

Data, research, theory and historical social paradigms appear to affect individuals' perceptions about issues related to gender differences in high school physics participation and achievement. (These factors will be discussed in more detail in Chapter 2, The Background.) These perceptions in turn affect their actions in relation to these issues either consciously or unconsciously. One such action is the process of creating a new science curriculum. I decided to locate my research within a historical period of science curriculum revision in Alberta and to look specifically at how concerns (if any) about gender differences in achievement and participation were reflected as actions in that revision. The following general question would frame this historical case study:

To what extent did curriculum planning reflect a response to concerns about gender differences in science participation and science achievement (as measured by large-scale assessments)?

There is an intersection of three different traces of history implied by this question. The data produced from international and provincial science exams along with participation rates are discussed and concerns are expressed. Research on gender differences in science achievement and participation and on science education is conducted and debated academically and publicly. New curricula are produced. Do these traces intersect in a way that shows evidence in the specific product of a program of studies and directly associated curriculum documents? I decided to focus the case study around the following questions in addition to the general question:

What was the publicly documented discourse of concern surrounding gender differences in physics participation and achievement at Alberta Education during a period of physics curriculum revision from 1984 to 1994?

Was this discourse translated into specific documented 'actions' in the Physics 20-30 Program of Studies and directly related curriculum documents?

What conditions seem to support the translation of documented concerns into actions and what conditions contributed to inaction on some recommendations?

This research investigates the reflection of the extent and nature of discourse on gender issues as it is revealed in documents related to the production of the *Physics 20-30 Program of Studies* in Alberta. The historical-social context influences the issues perceived as important by the individuals involved in the production of new curricula. The educational data that are collected directly by the government and other available data influences what issues might be raised as concerns and acted upon. The discourse in documents is a summary and a synthesis of the relative importance of these influences.

Secondly the research investigates the impact of the discourse on gender issues on particular documents – those that represent public curriculum in the form of a program of studies for Physics 20-30 or educational policy related to implementation of that curriculum by teachers. The research on gender differences in achievement and participation influences how these issues are perceived and the operational definition of equity that is acted on within the agency of government influence on curriculum. The political priorities of the government at the time directly affect the action priorities of the government. Action on gender issues are further influenced by the theories of feminists and the types of actions they promote particularly within the context of education. Dominant discourses on the nature of science and science education influence what actions on gender issues might be proposed and acted upon. These influences are synthesized within the *Physics 20-30 Program of Studies* document and directly related documents as actions related to gender issues.

Finally the research reflects on those conditions which appeared to support a translation of discourse on gender issues into action. Those conditions that support actions on gender issues may be reflected in the text of the documents themselves or implied from analysis of the recollections of individuals involved in the process of

producing action in response to discourse on gender issues.

Delimitations

Gender differences in physics participation and achievement (as measured by large-scale assessments like TIMSS) are issues that have been and are discussed in Canada and Alberta. The discourse would exist in many locations at the same time. Each of these locations is not isolated from any of the others, since individuals exist in more than one social location. By focusing on one location, the science curriculum revision process at Alberta Education, I hoped a more in depth analysis could be achieved. Within this location only one science curricula was examined, the Physics 20-30 curricula. This science was chosen because gender differences in participation in physics appeared to generate more discourse as an issue than gender differences in participation in biology or chemistry. The *Physics 20-30 Program of Studies* and directly related documents were the primary locations examined for actions related to gender issues. Public documents related to its production and interviews with individuals involved in some capacity with its production were used as evidence of discourse and the relationship between discourse and action. The science curriculum revision process in Alberta began in 1984 with a review of all secondary school curricula in Alberta. In 1995, the new Physics 30 program of studies was implemented province-wide in Alberta. Therefore the study was delimited to the time period from 1984-1995 in Alberta.

Limitations

The process of producing a 'physics curriculum' in Alberta did not occur only during creation of the *Physics 20-30 Program of Studies*. The interpretation and realization of the document was negotiated at many other places, most importantly the individual physics classroom. Locating my research in this location does not imply that the best or most effective place to affect change in gender differences in participation or achievement in high school physics is the *Physics 20-30 Program of Studies*. This is only one possible location for action. However, it is a document that influences physics education across the province, while other measures might be more localized in effect. It influences the text resources for the course and the Physics 30 diploma examination

directly. These in turn influence physics education in Alberta. The program of studies is a public document and many of the documents that are used to produce it are public documents. In this way they may be read by and influence a wide segment of society. The documents may also initiate secondary reports in media sources that also influence society as a whole. Actions taken in one location and even the discourse surrounding issues can also influence and encourage change in other locations. For this reason it was determined to be a useful location from which to investigate the public discourse on gender issues and their relationship to actions taken on those issues. This is both a limitation and delimitation.

Another limitation of this study is that some documents related to this science curriculum revision in Alberta may not have been located. My knowledge of which documents might influence the *Physics 20-30 Program of Studies* production was incomplete. I used the documents themselves to identify the most likely documents that might influence their production starting at the program of studies. I used literature searches to identify other documents related to the program revision. Some documents were suggested to me or given to me by Alberta Education staff. However, some other documents were obtained by looking at documents filed close to documents previously identified in the Alberta government's education library. These documents were located by chance not through searches or references from other documents and there may have been other similar documents that I did not locate.

Large numbers of individuals are directly and indirectly involved in the process of creating the *Physics 20-30 Program of Studies* and the documents and policies that inform its production. In this study the number of individuals interviewed was limited to four. Choosing the individuals to interview was largely based on where gaps in the relationship between document discourse and action seemed greatest and who seemed from the documents to be able to shed light on these gaps.

In a historical study the memory of the individuals directly involved in the process may make it difficult to recall the relationships between these documents and the role that they played in decision making clearly. The memory of participants regarding the significance of documents to the process of this science curriculum revision can be

assumed to be incomplete. Some of the documents were produced 18 years earlier. However, the more significant the relationships between documents and the issues investigated were in the view of the participants the more likely they would be to recall those relationships. The more often a particular document was referred to in the process of curriculum revision the more likely it would be recalled as significant by the participants. Acknowledging that this memory process is incomplete, the interviews still helped to identify connections between gender issues and actions in the program of studies and the influence that specific documents had on the curriculum revision process. Evidence within the documents could be used to support these identified connections.

My interview questions might limit the information provided by individuals as well. For this reason the interview questions were designed to start open-ended and only become more specific if information that was important to the study was not initially discussed by the interviewee.

Documents are not influenced directly by the researcher in the way that an individual in an interview can be influenced. However, the interpretation of the documents was both limited by and influenced by my historical-social context. In my discussion of method for this study, I describe this context.

Miles and Huberman (1984) suggest that the production of a conceptual framework can be used as an aid to focus and limit data collection. The framework helps to start the limitation of data collection from all of the data that are available. The process of this selection is a limitation of the study and the types of questions that can be asked about the case that is being investigated. By producing the framework the researcher indicates what they have paid attention to and what they have ignored. Miles and Huberman (1984) explain the relationship between the framework and data collection:

> [This] forces the researcher to be selective – to decide which dimensions are more important, which relationships are likely to be most meaningful, and, as a consequence, what information should be collected and analyzed. (p. 28)

They contend that the framework "need not act as blinders and straitjackets. As qualitative researchers collect data, they revise their frameworks..." (p. 29). The framework used in the initial data collection for this research is described in Chapter 3 (The Method).

The Background: Research on Gender Differences, Feminist Theory and Curriculum Revision

Overview

Gender differences in participation rather than gender differences in achievement generated the most discourse and concern during this science curriculum revision in Alberta, based on the evidence I collected. However, actions taken to increase the participation of girls in science courses relied partially on research designed to investigate gender differences in achievement. Several researchers suggest a link between achievement differences and participation differences (Caplan & Caplan, 1994; Haggarty, 1991; Halpern, 1992; and Williams, 2000).

Caplan and Caplan (1994) and Halpern (1992) suggest stereotypes about the ability of females to achieve in certain courses or participate in related careers can be reinforced by some of the research on gender differences in cognitive ability, even if such differences represent very small differences based on means. These stereotypes influence the perceptions of educators and contribute to observed gender differences in teacher-student interactions. The unequal interaction creates conditions where female students are less able to achieve and contribute to the lower confidence indicated earlier – a vicious cycle. Gender, achievement and participation of females in science courses and careers are linked through stereotypes that influence the environment created in schools and in society.

Gender differences in science achievement on large scale tests, particularly in the physical sciences, create questions about the possible causes of these differences. A large amount of research has been undertaken to investigate these differences. For example a meta-analysis of gender differences by Halpern (1992) reported in a book titled *Sex Differences in Cognitive Abilities* suggested that there were "thousands, perhaps even tens of thousands, of research reports" (p.47) on sex differences related to cognitive abilities. In her analysis she had to select a sampling of this research based on criteria. She describes many of the problems in selecting from such a large body of research since:

> Different experimental methods have sometimes been used to answer the same questions, and their answers do not always agree. Different results have frequently been obtained with the same tests, and similar results have been interpreted in different ways by different experimenters. (p.20)

Of the hundreds of articles referenced in this book, many from the 1970s and 1980s, only three references were duplicated in two sources of references connected with the Alberta science revision. However, these sources, one a chapter in the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) titled "Teaching with a Gender Balance" and the other a report produced for Alberta Education by Harvey Social Research Ltd. (1985c) titled *Factors that Differentially Affect the Schooling of Females and Males* contained research related to many of the same hypotheses on gender differences in cognitive abilities as those described in this book.

Curriculum as a site for action on gender issues has primarily been promoted by feminist theorists. However, resistance to secondary science curricula change exists for a variety of reasons. Some science curricula have been developed based on feminist conceptions of science education. A few examples of physics curricula designed to appeal to female students have been evaluated to determine their effect on girls' interest in and participation in secondary physics courses.

Hypotheses on the Causes of Gender Differences in Achievement

Hypotheses on the causes of gender differences in achievement (or more directly on cognitive abilities as reviewed by Halpern, 1992) can be broadly categorized into either biological or environmental causes. Controversy over gender research arises primarily because of tension between these two conceptions. A purely biological causal explanation would negate action on gender differences in achievement, a purely environmental explanation would imply that resources should be committed to achieving more equal outcomes by gender in educational achievement.

Research on gender differences in achievement influenced the equity actions that were promoted in Canada during the early 1970s. Feminists argued that gender differences in achievement, particularly in subjects like mathematics and the physical sciences, were not biological in basis but rather were a function of environmental

influences. Gaskell (1993) summarizes the arguments made by feminists and supported by research as:

> Feminists and researchers were arguing ... that sex differences were not as large as had been believed, were not biologically based, but were based in stereotypical and restrictive expectations coming from society and should be eliminated. (p. 149)

Gaskell describes how research on gender differences in achievement was used by the *Royal Commission Report on the Status of Women* to support its recommendations for action on gender differences in participation and achievement. The type of actions recommended by a government agency, like Alberta Education, to effect a difference in science participation are also influenced by the beliefs about the causes of gender differences in science achievement of the individuals involved.

Research on gender differences in achievement can be organized into broad categories of explanation or hypotheses. Caplan and Caplan (1994) and Halpern (1992) suggested different categories to organize these hypotheses. Based on these sources I organized research on gender differences in achievement and their relationship to gender differences in participation into five sections: achievement links to biological differences; effects of classroom gender stereotypes; masculine identification with the science curriculum; gender differences in psychological and sociological influences on achievement and gender differences in testing effects or bias.

Biological differences – Logic for and against. The type of evidence used to either support or refute biological differences follows some general trends. In each case it is important to note that inconsistencies in the definition and measurement of cognitive or achievement tasks varies greatly which tends to confound comparison. In Halpern's book (1992) the evidence for and against biological causes for gender differences in cognition follow a general pattern. Persistent differences in achievement on specific types of tasks are linked to hormonal or brain structure differences to support biological causes. Changes over time or within longitudinal studies in the degree of gender differences on specific tasks are cited as evidence to refute biological differences. Test construction bias and gender bias in rating the ability of males and females on tasks are also evidence she cites that refute biological hypothesis for gender differences.

Two examples of research that links hormonal differences between males and females to cognitive differences are illustrated by Moody (1995) and Kimura (1992). Both researchers linked differences on spatial tests to female estrogen levels and hypothesized that estrogen decreased the ability to perform spatial tasks. Males, who possess low estrogen levels, therefore have better spatial task ability. Gender differences in spatial ability are sometimes linked to higher achievement of males on some physical science tests.

Two examples of research that refutes this hypothesis are provided by Alderton (1989) and Noddings (1992). Alderton compared a group of females to males on spatial tasks a month after an initial test of their ability that consisted of multiple trials. He found that both groups had improved their performance and that the difference in performance between the two groups had decreased considerably. He hypothesized that the initial differences in performance on the task was a function of differential experience between the males and females and that the practice during the first trials helped to ameliorate this difference. Noddings (1992) used historical research findings as evidence that there has been a reduction over time in the difference between males' and females' performance on spatial tasks. She hypothesized that the differences were due to experience differences for males and females that had reduced over time leading to a reduction in these differences.

Different experiences – The gendered science classroom. By the early 1980s, feminists like Harding (1983, 1986), Kahle (1983, 1986) and Keller (1983) were theorizing that social paradigms had created a science culture that was essentially masculine. According to these feminists the paradigm was well ingrained in the social fabric – including the culture of schools. In science classrooms a litany of factors conspired to create a climate that discouraged girls from pursuing science. Textbooks and curriculum portrayed scientists as males. Teacher-student interactions and student-student interactions reinforced that science was for boys and not for girls. Role models of female scientists and within the classroom were in short supply. Current and historical recognition of scientists was primarily masculine.

Female and male students' interactions with their teachers and each other seem to

create classroom conditions that differ for each gender. Some of these differences appear to negatively affect female students' achievement and participation. Several research studies found that boys in many science and mathematics classrooms receive more feedback from teachers than girls and that this feedback is of higher quality. This could be expected to have detrimental effects on the girls' achievement (Cummins, 1998; Jones & Wheatley, 1990; Lawson, Penfield & Nagy, 1999; Li, 1999; Sadker & Sadker, 1986; She, 2000; Tobin, Kahle & Fraser, 1990). In some science labs girls participate less than males as a result of gendered student interactions that cast the girls in the role of recorders rather than active participators (Jovanovic & Steinbach King, 1998).

Participation in many high school courses, like physics, is optional. Students might be expected to obtain advice from teachers about the courses they should take. However, Riddel (1992) found that female high school students were given advice by both teachers and counselors that discouraged them from pursuing science-related subjects. The advice differed from the advice given to males of similar academic background. One reason might be that as Spear (1987) found, many secondary science teachers believed that: "Boys ... prefer subjects that can be described as numerical, science, logical and masculine; whereas girls ... prefer subjects that are verbal, arts orientated, intuitive and feminine" (p. 294). Another reason might be that some teachers attribute female students' achievement to effort while they attribute male students' achievement to ability (Fenneman, Peterson, Carpenter & Lubinski, 1990). The high achieving male students who are assumed to have a correspondingly high 'ability' in subjects like physics might be given more encouragement to continue than girls with similar achievement.

Students own perceptions of their ability can also be linked to limitations in participation. Survey data from SISS indicates that across Canada, female students' perception of their ability in science was lower than males at grades 5, 9 and 12/13 in the early 1980s (Connelly, Crocker & Kass, 1985a). More recently, DeBacker & Nelson (2000), in a study of 242 high school science students, found that girls still seem to report lower perceptions of their ability in science than boys regardless of their actual ability. This finding was true for physics, chemistry and biology courses. Williams (2000)

suggests that many girls choose subjects that they think they will do well in, and since on average they perceive their ability to be lower than boys in math and math-related subjects like physics relative to their actual achievement they participate less in these subjects.

Masculine images of science. Stereotyped perceptions of the attributes and values of scientists that are not compatible with many girls' values might also decrease their desire to participate in sciences. Sjøberg and Imsen (1988) created a five point scale of opposing paired-attributes that science students in Norway used to evaluate two categories of scientific researchers – *biology or medicine* and *physics or technology*. They found that both boys and girls rated scientists in fields of physics or technology as *objective and uncaring*. A parallel system for rating students' values found that girls in the "least person-oriented groups of girls (physics girls) are more person-oriented than the most person-oriented groups of boys" (p.236). The authors suggested that based on this evidence "the image of the physicist is nearly the negation of what girls value" (p.240). Jones, Howe and Rua (2000) found similar patterns of gender differences in 437 grade 6 students' attitudes towards science and scientists and in their own career interests.

A stereotyped perception that the physical sciences are more appropriate for males than females could negatively influence girls' interest in participating in physics courses. McLaren and Gaskell (1995) found in their study in British Columbia, that gendered interactions between boys and girls were grounded in both boys' and girls' perceptions of physics as a male domain and decreased girls desire to continue in physics courses. In a similar way Letts (2001) found examples in elementary and secondary classrooms that science, and stereotypes about scientific thinking were linked by male and female students to masculine traits. In one example a young boy is criticized by his peers both male and female for failing to be objective about studying a roach and instead reacting emotionally. This behavior is labeled by the other students as feminine. The interaction of the students both reinforces science as masculine and reinforces that boys should be better able to manage this "objective", "masculine" approach to studying science. Tobin, Kahle and Fraser (1990) also found evidence that science was reinforced by some teachers in Australia and the United States, as masculine and more suitable for

boys. The researchers describe the overall environment created for girls by Peter (one of the secondary science teachers in the case studies investigated) as: "Each comment is innocuous in itself, but each one suggests that science is okay for boys, who are rough, tough and bright, but that it is questionable for girls, who are lovely, charming and bored" (p. 95).

The *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) references research related to the masculine stereotypes of science in several sections of the chapter titled "Teaching with a Gender Balance". This link is clear in the following advice to teachers:

> As teachers we can monitor our covert messages and not unthinkingly cause our students to limit their choices. Jokes and innuendoes implying the inadequacy of women in science should be eliminated from everyday conversation. (p. S.3P-7)

Several other strategies suggested for teachers are linked to research on stereotypes about girls' ability in science and their suitability for science careers.

Psychological and sociological factors – Linking perception to participation. A variety of factors are linked to students' motivation to achieve in science courses and to continue in science courses or professions. Eccles created a model in 1987 (as described in Halpern, 1992) that describes a complex interrelationship between many of these factors and their affect on achievement and career choices. Many of these factors are related to gender role stereotypes held by the individual and reinforced by socializing influences that have already been discussed. There are also factors related to previous achievement experiences of students that influence student interpretation of their relative control over their achievement and factors related to career aspirations. Other researchers have used this model to investigate gender differences in participation in science courses and science-related careers.

Alting and Pelgrum (1990) used data from SISS to investigate the relationship between some of the variables in the Eccles model as measured by a student involving grade 9 students from the Netherlands. They found that girls, as compared to boys, perceived science as more difficult and less enjoyable. In their conclusion they suggest more research on the relationship of these variables to student achievement and motivation to study science.

Achievement data and attitude survey data for Canada from the SISS study correlated by Conner, Crocker and Cass (1985a) revealed that the strongest significant correlation to school science achievement (including high school physics) was the "importance of school science". Males perceived science to be more important than did females at all levels of schooling and their science achievement was also higher. However, compared to grades 5 and 9, the gender difference in attitude towards science was smaller for grade 12/13 science students. The percentage of female students surveyed that planned to pursue science-related careers was also lower than the percentage of males with this goal (Western provinces: 42.4% males, 29.9 % females). This suggests that achievement in science, perception of the importance of science and plans to pursue science careers might all be linked as proposed by the Eccles model.

The relationship between career-choice and the Eccles model was also investigated by Lupart, Pyryt and Cannon (2001). They created a survey related to careers based on the model that they administered to 850 grade 7 and grade 10 students in and around Calgary, Alberta. They found that both males and females were interested in careers that were interesting and challenging, that made the world a better place to live and that allowed a balance between work and home. Males rated earning a lot of money and high status significantly higher than females although both rated these factors as important. Preferred professions followed relatively traditional gender patterns. The top career choice for females was *artist*, followed by *health-related profession* and *other professions (like lawyer, accountant, architect, stock broker)*. Males top career choice was *information technology profession* followed by *other profession* and *science or math-related profession (like engineer, architect, geologist)*. *Science or math-related professional* ranked sixth for females out of a possible 13 choices. Females disagreed with the statement "men are better than women in science and engineering". Males also slightly disagreed but there was a significant difference between males and females. The authors suggest that the causes for gender differences in career choices require further investigation. Career aspirations, according to the Eccles model, influence both course participation choices and achievement in courses.

Measuring science achievement differences – Test effects. Sources of data on high school physics achievement in Alberta were described in the introductory chapter (Locating the Research). Although the international achievement tests indicated that significant gender differences in achievement in high school physics existed world-wide in 1984 and continued to exist in 1995, some researchers question whether these differences actually indicate differences in ability between males and females. For example, Alting and Pelgum (1990) found that the gender differences in achievement on the physics portion of SISS in the Netherlands, were much greater than those for the classroom grades. They hypothesized three possible causes for this discrepancy:

- nature of the test: multiple choice v.s. the open-ended questions mostly used in school practice
- context of the experience: more in agreement with boys' experience and interests than with girls'
- opportunity to learn outside the school: boys have more physics-related out-of school experience than girls, and the SISS tests contain items for which the Opportunity to Learn (OTL) at school was low, whereas school tests always concern subject matter previously treated in class. (p. 435)

Since similar gender differences in achievement were reported on the SISS in Canada, the same hypotheses could be related to these results.

There is evidence to support the hypothesis that the format of examinations differentially affects female and male achievement. In a review of performance by gender according to format type on a dozen large studies in Britain by Gipps and Muphy (1994 as reported in Lokan, 1999) the researcher found that "boys … perform significantly better than girls on the multiple choice component of the assessment while the reverse occurred for the essay component" (p. 298). Lokan (1999) found that gender differences in science achievement were much smaller on the performance portion of the TIMSS than the main test which was about three-quarters multiple-choice questions. A study by the Educational Testing Service (Cole, 1997), reviewed and analyzed gender differences on over 400 different large scale tests and concluded that the format of a test affects gender performance. Based on their review, the authors suggested that high-stakes tests "focus on skills on which males show higher performance" (p.21) while "some skills on which females excel, though important, have either been overlooked or have been

difficult and expensive to measure (such as writing)" (p.22).

Some researchers have found evidence that the context of science questions on some tests favors males over females because they refer to experiences that they are familiar with. A negative emotional reaction to some science contexts also negatively affected female students' achievement more frequently than male students (Erickson and Farkas, 1991; Hamilton, Nussbaum & Snow, 1997). Others found that the background experiences, including the number of courses taken in sciences and mathematics, created gender differences in science achievement on many large scale tests but did not indicate differences in ability (Hamilton, 1998). Still another factor suggested as influencing gender differences in achievement is gender differences in the appeal of a test or question context (Littleton et al., 1998).

Physics 30 diploma examinations currently contain both multiple-choice and long-answer questions. As discussed in Chapter 1 (Locating the Research), gender differences in achievement in high school physics in Alberta as measured by the Provincial diploma examination for Physics 30 are smaller than gender differences in physics achievement as measured by TIMSS for 1995-96. The gender difference in achievement as measured by the school-awarded mark for students in Physics 30 in the 1995-96 school year was small and in favor of female students. Differences in evaluation format, context or content might contribute to the relative differences in achievement by gender in the various evaluations of physics achievement in Alberta. Assumptions about which evaluation is best at measuring achievement in physics and therefore which evaluation is "correct" is a socially constructed value.

Newspaper articles provide evidence that achievement on international tests influences government policy decisions in Alberta and Ontario (Puk, 1999). Motivation of individuals involved in policy decisions related to science education, female students' perception of their science ability and teachers' assessment of female students' ability could potentially be influenced by the reporting of gender differences in science in Alberta. If gender differences in physics achievement were seen as an issue this might influence actions related to physics curriculum revision. If gender differences in science achievement were not seen as an issue, based on this data, then the root of participation

differences in physics courses in Alberta might also be viewed differently, with different implications for physics curricula revision. These views can be formalized in the operational definition of equity that is used within an organization like Alberta Education.

Definition of Equity

Action on gender differences in achievement or participation depend on the definition of equity either consciously or unconsciously subscribed to by policy makers. An organization is not necessarily uniform in its adherence to an equity definition and it is not necessarily stable over time within an organization. As the organization changes, the individuals within the organization change and the larger societal concerns change – in the process the equity definition also evolves both for individuals and in the stated policy of the organization.

Gillborn and Youdell (2000) identify four different uses of the concept of equal opportunity, or different operational definitions. These are identified as *formal equality of access and provision*, *equality of circumstance*, *equity of participation (treatment)* and *equity of outcome*. They elaborate the operational meaning of formal equality of access and provision by stating that "inequality by this definition would rest on members of one or more social or ethnic groups openly being denied access to particular schools or examination systems on the basis of their ascribed identity" (p. 2). Equality of circumstance they describe as "concerned with the inequalities of circumstance that can bar certain groups from participation in practice (especially via poverty) despite the abolition of any formal barrier to access" (p. 2). Equity of participation (treatment) they describe as localized more within the direct experience of schooling itself as revealed in structures and processes within the school system. Operationally they suggest this would result in actions such as eliminating tracking if it contributed towards inequalities between identifiable student groups. They explain that equity of outcomes "refers to the result of educational processes: the equitable distribution of the benefits of schooling. Equitable outcomes of schooling would decrease, if not eliminate, group differences in school achievement, attitudes, dropout rates, college attendance, and employment" (p. 3). The authors go on to explain that this concept of equity makes the assumption that

"there is no inherent reason why members of one socially defined group should not achieve average results on a par with any other such group" (p. 3).

These four operational definitions of equity can be used to examine this concept at Alberta Education during the period of science curriculum revision from 1984 to 1995. Individuals who were involved in the science curriculum revision who believed in equity of outcomes would be more likely to feel that action should be taken to address large gender differences in participation in high school physics courses. This might be reflected as action within the Physics 20-30 Program of Studies, a type of curriculum policy.

Curriculum Change

Curriculum policies, according to Eisner (1992), are ideologies that he defines as: "beliefs about what schools should teach, for what ends, and for what reasons" (p. 302). He describes that in the political process of creating curriculum, compromises between these ideologies are created. Roberts (1988) described this type of compromise related to differences in the ideological beliefs of participants in a science advisory committee in Alberta.

The "what to teach" for high school science curricula has been influenced by the historical association of secondary curriculum with specialized subject areas (Goodson, 1984, 1985, 1993, 1994; Giroux, 1999; Hargreaves, 1989; McIntosh, 1984). Goodson suggests, based on historical research, that aligning curricula to a subject area as defined by the subject specialization common at universities transfers power and status that can be used to obtain resources for that subject area. Some theorists suggest that subject areas are associated with power that is hierarchical in nature, with the physical sciences and mathematics highly regarded in relation to other subject areas such as the arts (Goodson, 1984, 1985, 1993, 1994; Harding, 1983). Resistance to curriculum change in sciences, like physics, is made problematic by the adherence of teachers to a subject culture and the high status of physics as a discipline within that culture. Giroux (1999) describes how this culture is "representative of those features of the dominant culture that it affirms, sustains, selects, and legitimizes" (p. 37) and therefore is political in nature.

The culture of education as Hargreaves (1989) suggests, is sustained relatively unchanged over time, because in the process of being educated themselves future

teachers are schooled to replicate teaching practices that exist. Unlike other occupations they have spent 12 years observing the practice of teachers before they are formally educated and enter a stable culture of teaching after their education. This makes curriculum revision designed to change teacher practice difficult. According to this theory, teachers in the science disciplines would tend to teach science in the same way as they were taught. Eisner (2000) suggest in a similar way that the "school as an institution is more likely to change the incoming message [of curriculum policy] than the message the institution" (p. 347). These factors might create resistance to science curricula change designed to impact female students' participation in science.

Eisner (2000) suggest that teachers' input is necessary to overcome resistance to change, to provide the insight of practitioners of the "art of teaching" into the conditions that effect implementation of new curricula and the substance that should be included.

Students, as well as teachers, need to have their input into equity policies including curriculum interventions. Kenway and Willis (1998) collected evidence about students' perception of the impact of equity policies, including curricula changes, on their classroom experiences. The overall conclusion of their study is that at the classroom level, for students, equity interventions and policies have unpredictable and in some cases contradictory effects. For example, one girl suggested that she hadn't felt she couldn't do math until advertisements at the school designed to attract girls into math courses insinuated that they were less able than boys. Any revisions of the high school physics curricula in Alberta that were designed to address gender differences in participation or achievement might not have their intended effects at the classroom level because of the impact of unpredicted effects. Input from students who experience the physics curriculum in Alberta might help to identify actions on gender issues that would address some of the inconsistencies between the intent of actions and the gendered effect of these actions on students.

Evaluation of curriculum actions designed to increase the interest in, participation in and or achievement of girls in physics courses exists. However, research-based evaluation of the effectiveness of various interventions is not always followed by policy-makers (James, 1993; Scott, 2000). Research may be selectively presented and ignored,

or new priorities, perhaps due to a change in governance, may contribute to ignoring findings from an investigation based on previous political priorities.

Curricula revision as a possible site of action on gender issues is affected by resistance to science curricula change by subject area specialists, by the engrained experiences of educators related to what science education is and by the unpredictable interaction of any policy intervention, including curricula revision, with other factors in the science classroom. Teacher and student input into the process of curriculum revision might reduce resistance and improve the effectiveness of any actions taken on gender issues. Political priorities may also affect the actions that are implemented. The impacts of some of these factors on science curriculum revision in Alberta are described in more detail in Chapter 4 (The Context). Despite the difficulties inherent in curriculum revision, feminist theorists use research to support curriculum as an important site for action on gender differences in achievement and participation.

Feminist theories - The masculine curricula. Curriculum revision as a site for action on gender issues, starts from feminists' critique of the basis of knowledge production and the valuation of some forms of knowledge over others. Noddings (1995) suggests that a male standard permeates the curricula that exist, particularly in secondary schools. She believes that a change towards a curricula with a "social consciousness" should occur to recognize "issues and practices that have long been central in women's experience" (p. 372). Smith (1991) theorizes that concepts of knowledge in subject disciplines should be critiqued and reinvented by "subjecting [them] to exacting scrutiny and criticism from the position of women as subject (or knower)" (p. 253). In her view a masculine perspective of knowledge in society has influenced the creation of subject disciplines and only scrutiny of this bias can reveal the assumptions that it is based on.

Other feminists (Harding, 1986; Keller, 1983; Lather, 1991) have questioned the nature of science curricula in a similar way. Keller (1983) uses character analysis surveys of scientists to suggest that masculine characteristics predominate in individuals who choose science-related careers. She suggests that women's ways of practicing science differs from males (using examples of female scientists such as Barbara McClintock) and feels this should be reflected in the education and practice of science disciplines. Osborne

and Barton (2000) feel that the knowledge constructed in science "reflects power differentials in our society [that favor] … white, male, middle-class cultural values" (p. 51) and also suggest curriculum reform to counteract this bias. Gough (1998) suggests that science knowledge has been constructed as a western-based, male-centered paradigm of knowledge. She feels that science education research should draw attention to instances of racism and gender blindness in science education. Feminists such as these suggest re-envisioning the nature of knowledge of the physical world to be more inclusive of "feminine" understandings. Canadian education policy related to curriculum has been influenced historically by the work of feminist theorists like these.

Feminist impact on curricula – Historical perspective. Gaskell (1993) describes three different feminist positions in Canada with respect to education, and frames these within three historic periods. The first period in the 1970s was prior to this science curriculum revision, the second period encompassed the revision period of the 80s and the last period occurred as the curriculum revision was being implemented in the 90s.

The first of the positions she describes seeks to "eliminate the difference gender makes" (p. 146). In this position Gaskell states that there are attempts to "make women more like men so that they can compete equally for rewards" (p. 146). This leads to equal rights policies as well as research that "emphasizes the role of nurture over nature and documents and critiques the different and unequal treatment that girls and women get in schools and society" (p. 146). She describes how in the 1970s in Canada the *Royal Commission Report on the Status of Women* sponsored a study on sex-role imagery in textbooks used in Canadian schools and opened up discussion and research on the "intangible social relations of sex role stereotyping by teachers, parents and school practices" (p.150). According to Gaskell one of the effects this focus by feminists had in Canada during this period was that: "Publishers and ministries of education across the country appointed advisory groups on sexism and began to issue guidelines for doing away with stereotyping in materials and in classroom practices" (p. 150). Teaching practice was suggested as an important location for action on equity. The impact on curricula policy was directed towards stereotyped images of females and males in resources and curricula.

Gaskell's analysis is that the late 1970's and 1980's in Canada marked a shift in thinking of some feminists towards "revaluing the female". Gaskell describes revaluing the female as: "the problem is not that women are different from men, but that they are valued so much less" (p. 146). During this time research by feminists was designed to "critique the institutional structures that continue to exclude and devalue female characteristics and the people [that have them]" (p. 147). Feminist theorizing during this time period "rethinks knowledge, curriculum, and school structures as reflections of male power, and is concerned less with individual mobility than with redressing the power balance between men and women" (p. 147). Gaskell describes one of the policy strategies of this time period "involves a wholesale rewriting of the curriculum so that women's traditional concerns are included" (p. 153). Watras (2002) describes the influence of feminist advocates on education in the United States that closely aligns with the stages described by Gaskell in Canada. In the 1980s, he describes how feminists such as Betty Friedan and Nel Noddings advocated a change in emphasis towards valuing what they described as females' traditional concerns towards family and relationships. These feminists promoted curricula that emphasized caring relationships. McIntosh (1984) also described the history of re-envisioning curricula from a feminist stand point. She includes as three final stages, curricula that question the construction of knowledge as masculine, curricula that reverse the systematic undervaluing of women's contributions to knowledge and finally curricula that recognize the diversity of contributions to knowledge.

McLaren and Gaskell (1995) suggest one way to revise the curriculum to address continued sexism they observed within the science classroom that appears to be unrecognized by female students. They feel that it is necessary to make "gender (in all its differences) an explicit part of the science curriculum" (p. 153). Questioning the historical forces that affect the participation of women in science is an example of how gender could be made explicit in the science curricula. As will be revealed in Chapter 6 (The Actions), two resources that influenced this high school science curriculum revision in Alberta suggested this type of critique (American Association for the Advancement of Science, 1989; Committee on Tolerance and Understanding, 1984b).

Gaskell and other historical researchers suggest that curriculum was a site for action on gender issues in the 80s. "Girl-friendly" science curricula are one example of actions that were designed to respond to gender issues.

Science curricula designed to increase female's interest and participation. A variety of science curriculum revisions have been designed in response to low participation of females in physical science courses. Many suggest links between science and society. In Alberta, a Science, Technology and Society emphasis (STS) was part of the science curriculum revision that started in 1984.

An early example of linking science to society to appeal to girls was the science curricula developed in Norway as described by Sjøberg and Imsen (1988). Their girl-friendly science curriculum included context which stress "the use of science to improve life for ourselves and other people" (p. 145). These researchers felt that a "lack of a context also may be perceived as a particular context by pupils; that is, science will then be understood as something remote from real life both on the personal and the societal level" (p. 245). They suggest that science should be portrayed as a social process "constructed by people with different interests and values" (p. 245).

Many of these ideas are echoed in STS curricula elsewhere. For example, Eijkelhof and Kortland (1988) and Jörg and Wubbels (1987) evaluated a STS based curriculum for physics developed in the Netherlands called the Physics Curriculum Development Project. Units within this curriculum were project-based and physics concepts were integrated with societal decision-making concepts. Student surveys indicated an increase in interest in physics. Students were most positive about student activities and the applied nature of physics, the STS connections, in the units. Girls and boys liked many but not all of the same units but girls particularly liked the unit where the context was medical. Ramsden (1990) describes a project carried out from 1983-87 to develop a physics curriculum that was more girl friendly for 13 and 14 year-old girls in Great Britain. Some of the aims of this curriculum were as follows:

- The material would be varied in approach, including the use of open-ended and problem-solving exercises and creative writing, discussion and role-play debates as a means of developing the understanding of new ideas.
- Where possible, physical science principles would be related to the human

body.

- The material would stress social and applied aspects of science. [three of eight listed aims for the curriculum] (p. 50)

In addition to an increase in positive student attitudes towards the physics topics in the curricula, the researcher also found an increase in students' choice of physics for a course the following year. She also noted that the "physics specialist[s] expressed less concern than the non-physics specialists over the need for changes in approaches to teaching the subject [and] the physics specialists also appeared less confident with the new approaches in the unit than the non-physics specialists" (p. 53). She hypothesized that this resulted in a non-significant change in ranking of the curricula as enjoyable in the classes taught by the physics specialists as compared with the group as a whole.

Many of the same STS connections are suggested by Rosser (1993) for altering science curricula to make science more appealing to females based on research findings. However, she also believes that curricula should "formulate hypotheses focusing on gender as a crucial part of the questions asked" (p. 7) in order to focus attention on the bias of some science research that assumes a male norm. She provides sources of information on the barriers that historically prevented women from entering science and contributing to its knowledge base that she also feels should be a part of science curricula.

Unfortunately as Hughes (2000) cautions, curriculum revision to make science more girl friendly can reinforce gender stereotypes. She investigated the impact of a science curriculum with a large STS component on classroom interactions and found that the scientific "body of knowledge" was associated with able students by teachers and they felt that only girls enjoyed the socioscientific context. Hughes states that "the very association of a more socially relevant curriculum with female students may be counterproductive because this reinforces the association between males and abstract science" (p.438). Solomon (1986) also cautions, based on research evidence, that "those features [of STS] which might attract girls to science – openness and capacity for helping people – are at the opposite extreme to those for which adolescence boys so often choose to study [science]" (p.274).

More recently some researchers and theorists suggest that curriculum revision in

science should reflect the diversity of individuals and the world. Osborne and Barton (2000) tried to reflect this by designing science curricula that address the needs of females, minority, low-income students. In a similar way, Kumashiro (2001) creates a vision for a post-modern curriculum for many subjects including science, based on research findings. In his vision he describes science curricula where students:

> Simultaneously learn new knowledge, while critiquing the very ways we come to know; simultaneously learn about the contributions of science and math, while exploring ways that science and math have closed off further learning, privileged only certain knowledges, and in the process, contributed to oppression. (p.7)

A science curriculum that reflected these priorities might be a vision for future science curriculum revision projects.

Evaluation of Other Intervention Strategies

A variety of other interventions designed to increase women's participation in science have been evaluated. Some of these evaluations are related in some way to interventions taken in this Alberta science curriculum revision. One of the most consistent and persistent findings of research on gender differences, is that teacher-student interactions are gender biased. The persistence of this teacher behavior over a long period of time suggests that interventions to change the behavior have either not been implemented or were not successful. However, Tracy and Lane (1999) worked with 405 undergraduate pre-service K-8 education majors on an intervention that was successful in changing this behavior. The teachers were taught how to use a self-evaluation instrument called "The Gender Equity Observation Form" to assess their videotaped interactions with students during a 15 minute teaching lesson. The researchers found that after using this self-evaluation tool over a period of time, the teachers' interactions with students were far more gender neutral than the control group and more reflective of good teaching practice based on the research that supported the self-evaluation tool. This suggests that gender differences in teacher-student interactions might be changed by very specific interventions that allow teachers to observe and self-correct their own behavior.

An initiative called the Girls Into Science and Technology Project was a four year

cooperative research project undertaken with researchers and the staff of 10 comprehensive schools in the U.K. from 1980 to 1984 (Myers, 2000). Strategies of the project included: classroom visits from female role-models in science; observation and feedback of teacher-student and student-student interactions in the lab or in workshops, designed to change inequitable interactions; sessions with parents to discuss the consequences on career opportunities of choices related to science course selection and class discussions about the difficulty of making non-traditional course and career choices (paraphrased from a list on p. 144). The researchers found that students' gender stereotypes related to science decreased dramatically and there was an increase of 4 %, compared to previous years, in the percentage of girls enrolling in secondary physics courses.

Another project in the U.K. was the Women into Science and Engineering campaign (Myers, 2000). They sponsored conferences and career events where local women, employed primarily in engineering, talked about careers in science. An increase in the percentage of women enrolled in engineering and technology from 7 % in the mid-1980s to 14 % in 1997 was used as evidence that the program was partially successful. This is similar to a program in Alberta called Women in Scholarship, Engineering, Science and Technology (WISEST).

Summary

The available research on gender differences, equity policies, and the impact of curriculum policy on the curriculum of the physics classroom in Alberta are part of the historical context in which any actions taken on gender differences in participation or achievement would take place.

Several hypotheses have been used as the basis for research on gender differences in science achievement. This research is also linked to gender differences in participation in science. Biological differences might contribute to gender differences in science achievement. Science classrooms seem to represent different experiences for male and female students, with female students negatively impacted. Science and scientists, at least in the past, have been stereotyped as masculine, negating female identification with the pursuit of science. Low perceptions of ability in science and gender role socialization

may negatively impact girls' interest and achievement in science. This is particularly unfortunate if the tests that measure achievement in science may be designed in such a way that female students are negatively impacted relative to male students. The perceptions created still affect female students (and their teachers) participation in science courses like physics.

The impact of this type of research is reflected in the operational definition of equity that individuals subscribe to. This in turn influences the actions that are taken by an organization to address equity issues. One place for taking action is the science curricula.

Locating curricula as a place for action on gender issues was influenced by feminist research and theory. The evaluation of physics or science curriculum designed to appeal to female students suggests that some of these curricular interventions may be effective in increasing female students' interest and participation in science. Some equity policies designed primarily to improve science classroom conditions for female students, also seem to be effective in increasing female participation in science courses.

The Method: The Historical Case of Physics Revision in Alberta

A Historical Case Study

Investigation of gender issues within the context of the development and implementation of a new Physics 20-30 curriculum in Alberta from 1984 to 1994 can be thought of as a historical case study. Creswell (1998) suggests some features of a case study that apply to this research. Cases are generally bounded by time and place, they involve multiple sources of data and the context of the case is described in some detail. In this research the case is bounded by the dates (1984 through 1995), the place of investigation (Alberta Education) and the specific actions taken in the Physics 20-30 curricula to address gender issues in physics education. Various types of documents and interviews with participants involved in some aspect of the curriculum revision process are used as data sources.

Merriam (1998) describes the historical case study as similar to other case studies:

> The key to historical case studies, organizational or otherwise, is the notion of investigating the phenomenon over a period of time. The researcher still presents a holistic description and analysis of a specific phenomenon (the case) but presents it from a historical perspective. (p. 35)

The specific phenomenon in this research is the interaction of gender issues with a historical period of science curriculum revision in Alberta.

Choosing the time frame. In 1984 a major study of science education in Canada by the Science Council of Canada included recommendations on gender issues in science. One of these recommendations was:

> Ministries should outline, in all policy documents relating to science and technology education, concrete steps to be taken by educators to increase the participation of girls in science and technology. (p.48)

This seemed to be a significant starting point since it would presumably generate discourse in Alberta Education as in other provinces across Canada. This is also the year that the Minister of Education in Alberta announced a review of the secondary curriculum (including science) (Alberta Education, 1984e). The discussion of gender

differences in participation could be expected to surface in the curriculum revision. The final implementation of new Physics 20-30 curriculum was the 1994-95 school year. A time frame from 1984 to 1995 was chosen for this case study, to incorporate the initial review of secondary education and the final implementation of new secondary science curricula in Alberta.

Advantages of the historical case study method. Mirriam (1998) suggested that case studies are "chosen precisely because researchers are interested in insight, discovery, and interpretation rather than hypothesis testing" (p 28-29). In this case study, there is no initial hypothesis, but rather an exploration of gender issues in the context of curriculum reform in science. Mirriam also suggests that this design is useful if the intent is to "uncover the interaction of significant factors characteristic of the phenomenon" (p. 29). In this research I looked for evidence of where data on gender differences in science participation and achievement (as measured by large scale assessments), research related to this type of data and curriculum policy (as reflected in the program of studies) interacted within the historical context of this time period. The intent was to determine conditions contributed to the translation of documented concerns into actions.

Case studies generally allow the researcher to investigate a particular phenomenon or issue in more depth by limiting the data collection to one or a relatively small number of locations. The limitation to one location is balanced by the collection of a larger variety of data within this location to obtain descriptive depth on that location or situation. However the trade-off is that there is less transferability of the findings in this research than in methods that investigate a broader sample of locations when studying a particular phenomenon. This case is most useful when interpreted in the context of Alberta's education system and the other available information about this science curriculum revision. Chapter 4 (The Context) contains background on this context.

Historical case studies have the potential advantage of hindsight in interpreting a phenomenon. The past can also be useful in understanding the present – particularly if parallel contexts are identified in the present. Cohen, Manion and Morrison (2000) describe this advantage:

> The ability of history to employ the past to predict the future, and to use the present to explain the past, gives it a dual and unique quality which makes it

especially useful for all sorts of scholarly study and research. (p. 158)

For the reader of this case study I hope that description and interpretation can be useful in understanding current curriculum discourse related to gender issues or other equity issues - particularly in the Alberta context. Alberta is currently in the process of revising its high school science curricula. Research and theory on gender issues that was not available during the 1984-1995 science curriculum revision was described in the background literature. Data on gender differences in physics achievement and participation collected during the time period along with more recent data can also be used in interpreting the case. This isn't possible in case studies situated in the present. Combining insights from new research and available data may also be useful in understanding some of the strengths and limitations of possible actions that could have been or were taken within the curriculum revision process. Some of these actions might be desirable in the current science revision in Alberta.

Overview of the Research Method

My initial data collection involved searches for curriculum policy documents that directly referred to gender issues in secondary physics during this time period. From those documents I discovered other documents related to their production. These documents contained recommendations and suggestions related to concerns about gender differences in achievement and participation. I analyzed the *Physics 20-30 Program of Studies* document and related documents for evidence of action related to these recommendations and suggestions. This initial analysis of these documents generated many questions and suggested some tentative themes. The next stage of the research was to interview individuals who would be able to describe the relationship between discourse of concern on gender issues and the Physics 20-30 Program of Studies from a participant view point. Discourse on gender issues in documents from a variety of sources, actions suggested in the Physics 20-30 Program of Studies and related documents and interview transcript evidence was triangulated to provide support for the interpretations related to the three research sub-questions.

Prior to investigating the documents I was unsure if there would be enough

evidence of discourse and action on gender issues to investigate the three sub-questions related to the study. There was evidence of both discourse and related actions on gender issues. Both the extent of the discourse related to gender issues within these documents and the nature of the discourse were important to this research.

Types of documents analyzed. I analyzed a portion of the publicly recorded curriculum documents produced by or for Alberta Education and related referenced studies and other documents. Several documents, such as the *Physics 20-30 Program of Studies* and recent *Annual Reports* of the diploma examinations program are available on the Alberta Education web-site, in schools and in post-secondary education libraries in Alberta. Physics teachers and other educators are the primary audience of these documents. Other documents were distributed to a wider public audience. An example is *The Secondary Education in Alberta Policy Statement* (Government of Alberta, 1985), a document that is addressed to the 'people of Alberta' and is signed by the Premier at the time, Peter Loughheed. Some of the documents I reviewed were located in the Government of Alberta education library but were not likely widely circulated or read such as the review of the implementation of the Science Council of Canada recommendations across Canada, a study undertaken by Orpwood Associates (1987).

The documents were created by or for Alberta Education, or were created by other agencies but referenced back in some way to the science revision process in Alberta. Public policy documents frequently support their positions through reference to commissioned studies, reports and surveys. Studies commissioned by Alberta Education are generally referenced with research and data. They are formatted to provide a summary of findings and in some cases tentative conclusions, suggestions and recommendations. Other documents related to the science revision process in Alberta contained recommendations related to science education as well. They were also supported by reference to research, studies and surveys.

Documents produced for the government sometimes stated clearly the nature of their mandate, the authors, the review committee's role and the anticipated nature of their contribution to government policy decisions. In other cases this information was not clearly presented. Policy documents (like the *Physics 20 -30 Program of Studies*) do not

have authors listed. However they are signed off and reviewed by the Minister of Learning and have a legal status. Many individuals have varying degrees of input into the production of these documents. In this way they can be assumed to be a summary of not only this varied input but of the relative influence of different individuals that participated in their production. They are a kind of record of the eventual influence of the other documents that were produced in connections with this science curriculum revision. They are a unique reflection of the final process of curriculum revision.

Each of the documents tells a slightly different type of story in respect to the discourse at Alberta Education on gender issues associated with the science curriculum revision. In this way a more diverse picture of the discourse is available although it remains incomplete. When the different document sources support the same interpretation of the nature of the discourse and/or action on gender issues, they are a form of triangulation of that evidence. In some cases the documented evidence about a particular action or gender issue, was contradictory or vague and interpretation in those cases is more tentative.

Goodson (1994) describes several reasons why in his studies of the history of school subject formation, the written documentation of curriculum was an important source.

> What is most important to stress is that the written curriculum, notably the convention of the school subject, has, in this instance, not only symbolic but also practical significance; symbolic in that certain intentions for schooling are thereby publicly signified and legitimated; practical in that these written conventions are rewarded with finance and resource allocation and with the associated work and career benefits. (p. 19)

The actions related to gender issues that were revealed in the *Physics 20-30 Program of Studies* and related documents would be symbolic of intentions related to gender issues. The program of studies has a practical influence on physics teachers, through the curriculum itself, its influence on physics textbook selection and its direct relationship to the Physics 30 diploma examination that grade 12 physics students write.

Locating related documents. My initial identification of documents to analyze involved education data base searches for documents that directly related to revision of the secondary science programs in Alberta during this time period. This resulted in a very

limited number of documents. In each of these documents I looked for gender references. One chapter in the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) titled "Teaching with a Gender Balance" contained the most directly related references to gender issues. The *Physics 20-30 Program of Studies* (Alberta Learning, 1998) contained no direct references to gender issues however the teacher resource manual included a section that described the rationale for the high school science program of studies. The teacher resource manual directly referenced three documents as primary influences on the curriculum revision:

> A number of factors have influenced the development of the Alberta Senior High Science Program. The Alberta Education policy paper, *Secondary Education in Alberta* (1985); the Science Council of Canada Report, *Science for Every Student* (1984) and the American Association for the Advancement of Science report, *Science for All Americans* (1989), were very influential in setting the goals, objectives and structure of the program.(p. S.1-3)

Each of these documents was reviewed and additional documents related to their production were also reviewed. For example the Science Council report had several research documents associated with its production, a report on the deliberative conference on Science Education in Alberta held in Red Deer to discuss the report's recommendations (Nay, 1983) and a follow-up study *Science Education in Canada, 1987: Science for Every Student + 3 years* (Orpwood Associates, 1987). Figure 4 shows the type of document trail that I used in this process for this series of documents.

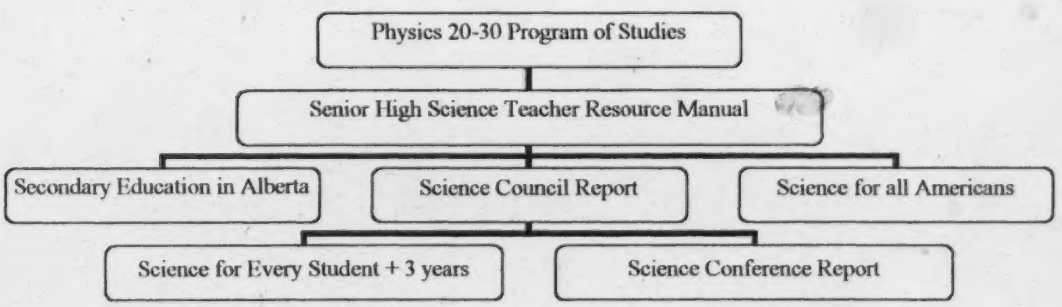

Physics 20-30 Program of Studies
Senior High Science Teacher Resource Manual
Secondary Education in Alberta
Science Council Report
Science for all Americans
Science for Every Student + 3 years
Science Conference Report

Figure 4: Document trail

Several general searches (ex. Alberta and science; Alberta and curriculum) using the ERIC data base were used to identify other documents related to the high school curriculum revision during the time period 1984-1995. *The Curriculum Audit Report: Volume 1* (Alberta Education, 1984b) was an important document identified in these searches. Several documents were located by browsing through the Alberta Education library in the areas related to other curriculum documents that were found in the original searches. These included the report prepared by Harvey Social Research Ltd. (1985c) for the Deputy Minister's Advisory Committee on the Education of Girls titled *Factors that Differentially Affect the Schooling of Females and Males: Final Report* and a report prepared by Meanwell, Weiden and Chase (1989) for the Program Equity Steering Committee titled *Program Equity Strategic Plan: Phase I: Development of an Operational Definition.* Some documents were suggested to me by Alberta Education employees.

Interpretive framework. During my background literature review and the early stages of reading the document texts some factors that seemed to influence the translation of documented concerns in to actions (or lack of actions) emerged. The interpretive framework presented in Figure 5 was a tentative outline of some of these early anticipated factors. While reading the documents I looked for specific references to these factors and evidence of how they affected the process of curriculum revision in reference to the gender issues investigated.

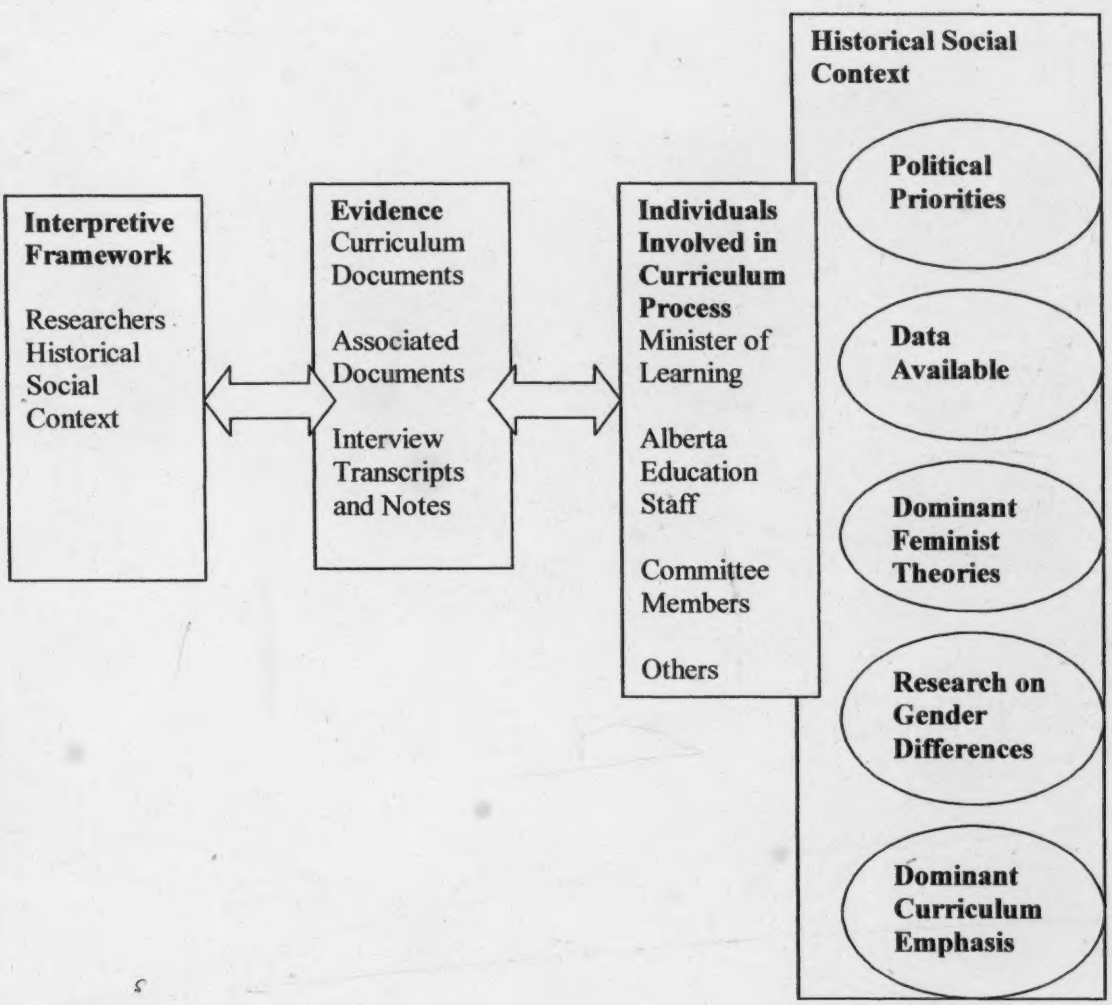


Figure 5: Relationships between variables of interest

A framework can be used as a tool to create codes for data as it is obtained. This coding can be thought of as part of the process of analysis. As more data is collected the framework can be revised and in the process codes may also be modified, deleted or added to. The purpose of the coding is to help organize the data in relation to the interpretive framework but not to quantify or reduce the data (Miles and Huberman, 1984).

Coding of documents and interview data was initially based on the "Historical-Social Context" categories in the framework illustrated in Figure 5 and the person or persons responsible for creating the document. Documents varied considerably in their reference to research or data. The way that data on gender differences in participation was presented also changed within the time period. The curriculum emphasis was referenced in many of the documents. Very few references were made to political priorities. Feminist theories were not directly referred to in any of the documents although they may have influenced research that was cited. The variation in authors and identification of authors was described earlier. Coding using the bins as a reference quickly became too simplistic for any meaningful analysis. However, it was useful in focusing my attention on the role that these factors may have had on the discourse on gender issues and the actions that were taken.

My own historical-social context is removed in time from the period that is investigated in this case study. Within this historical social context would be information that was not available at the time of the study to the individuals involved in curriculum discourse. This could produce a time-bias in my interpretation of the data. To partially uncover this bias I provided information in the background literature on research on gender differences and science curriculum revision related to these differences that seemed to be available in the time period of this curriculum revision as well as more recent data and research.

Later in this chapter I identify some of my background related to this research and the feminist traditions I identify most closely with. This is an attempt to reveal to the reader some of my possible biases as a researcher. This context is partial based on the limitations of my selection and the difficulty of identifying the available context that my

history creates while I am framed within its limitations.

Evidence in the documents. In each document I looked for direct references to gender issues. I also identified places where the recommendations or suggestions made in one document with reference to gender issues may have influenced another document. I looked for direct and indirect references to other documents. I documented these connections, including appropriate quotes or references within the documents on a document summary form. I made notes on events that were connected with the production of the texts. I also identified the type of authority the text had – policy, research study, commissioned study, referenced source, or supporting curriculum documents.

To begin with I used a coding system to identify this type of information. However the coding system appeared less useful than the notes that described connections between documents, particularly references to possible actions. During the process, as suggested in Miles and Huberman (1994, 1984) I added side notes (or memos) of possible questions about the documents, key individuals that were involved in its production or tentative themes related to the research questions. I moved back and forth between the documents – particularly referring back to the *Physics 20-30 Program of Studies* to look for connections between this document and recommendations or suggestions related to gender issues in other documents. This information, coding and initial analysis was recorded on a modified version of a document summary form illustrated in Miles and Huberman's (1994) text on *Qualitative Data Analysis* (p. 55). A sample of a completed document summary form is included in Appendix A.

Document summaries were used to create a flowchart that indicates the interrelations between the documents (Figure 6) and a time-line of when the documents were produced in relation to significant events in the science curriculum revision process (Appendix B).

Prior to the interviews, an initial analysis of the document evidence was completed. Relationships between the discourse on gender issues in documents, recommendations and suggestions in these documents related to gender issues, and actions in the *Physics 20-30 Program of Studies* and directly related documents were part

of this analysis. This first stage of analysis was used to create interview questions.

Miles and Huberman (1994) recommend this type of early analysis of documents for evidence related to research questions. The authors describe how this process "helps the field-worker cycle back and forth between thinking about the existing data and generating strategies for collecting new, often better, data" (p. 50). Fraenkel and Wallen (2000) also suggest that data collection, analysis and writing should be interspersed together in case study research.

Interviews with participants. After the initial document analysis I organized semi-structured interviews of four individuals involved in some aspect of the revision of the science curricula or other documents that related to gender issues. This type of interview format is common in a case study where the "primary intent … is to find out what people think and how the views of one individual compare with those of another" (Fraenkel and Wallen, 2000, p. 510). In this case their views on the connections between discourse on gender issues and actions in science revision process related to Physics 20-30 revealed in the documents I reviewed were compared.

Three individuals interviewed were involved in the discussion, review and/or production of the Physics 20 -30 program of studies in different capacities. A fourth individual was involved in the identification, production or discussion of the data on gender differences in participation or achievement in physics. Faenkel and Wallen (2000) call these individuals "key actors" that are able to provide excellent information because of specialized knowledge of a situation. Interviewing individuals that were involved in different aspects of the curriculum revision process is similar in intent to the analysis of different types of documents. Each individual involved in the process of curriculum revision would have a different perception of the discourse and action taken related to gender issues within the science curriculum revision. By choosing from the many individuals involved, four individuals from different locations within this process, I expected to reveal some of this diversity of perception.

The first questions asked during the interviews were general and designed to allow the individuals to describe any discussion or actions related to gender issues within the context of the science curriculum revision that they could recall. Questions about the

connections between various documents, the discourse on gender issues they implied and the Physics 20 -30 curricula identified during the initial document analysis were introduced in the interviews whenever initial general questions didn't prompt recollections of the documents and their connections. Fraenkel and Wallen (2000) describe the strengths of this interview format (interview guide approach) as:

> The outline [of possible questions, topics and issues to be covered] increases the comprehensiveness of the data and makes data collection somewhat systematic for each respondent. Logical gaps in data can be anticipated and closed. Interviews remain fairly conversational and situational. (p. 511)

I was able to respond to unanticipated information, issues and themes within the format of the interview. I was also able to direct the conversation to discussion of specific gaps in understanding that arose from the document analysis. This format also allowed me to share with the interviewees a sense of what I identified within the documents that referred directly to gender issues. In this way the communication within the interview was two-way. A copy of the general and specific interview questions is provided in Appendix C. Faenkel and Wallen (2000) describe the weaknesses of this interview format as:

> Important and salient topics may be inadvertently omitted. Interviewer flexibility in sequencing and wording questions can result in substantially different responses from different perspectives, thus reducing the comparability of responses. (p. 511)

In this case study the different perspectives were anticipated. The intent was to illustrate with a limited number of interviews as broad a perspective as possible of how the documents related to each other and to the issues investigated. Those topics most relevant to a particular individual were given priority in the interview process to ensure that they were not omitted due to time constraints.

Themes were identified during this stage of analysis that related to the conditions that seemed to support the translation of discourse to action. Evidence was examined to see if it supported each of the themes and where evidence existed to contradict these themes. During this process some of the themes were dropped for lack of evidence and several were revised slightly. An example of a summary document used to record this analysis for one of the themes is included in Appendix D.

Smith (1984) describes in her ethnographic historical study an approach that is

similar to this design.

> [Our methodological approach] follows the general inductive, interactive mode of our general research style. One learns a little here and a little there and those items play into each other and into later interviews, documents, reading, analysis and writing. (p. 159)

I used what I learned from the initial document analysis and in later interviews to re-interpret the original documents. The initial analysis of documents was layered with a deeper understanding from the interview process.

Validity

Cresswell (1998) and Mirriam (1998) suggest that rich thick description in the presentation of a case study contributes to its validity. The complexities of the case can be illustrated by this description and "the researcher enables readers to transfer information to other settings and to determine whether the findings can be transferred" (Cresswell, p. 203). In this case the relationships and contents of the documents as they relate to gender issues are described in detail.

Many researchers suggest triangulation through the use more than one type of data source to improve the validity of findings in a case study (Cresswell, 1998; Miles and Huberman, 1994; Mirriam, 1998). In this case I used a variety of documents from different sources and interviews from several participants as sources of data. The documents used to create the initial analysis were from different sources and authors. The purpose of the documents and their intended audience differed. Some were produced by or for Alberta Education while others were accessed by the science curriculum team to support their work in curriculum revision. Interview evidence came from different participants, who had different viewpoints of the science revision process. This variety of sources provided triangulation during analysis of the data.

Cresswell (1998) and Miles and Huberman (1994) suggest checking interpretations by looking for negative evidence. The interview evidence and document evidence was examined for negative evidence related to the extent of discourse and the nature of the discourse to action relationship. Themes were checked for negative or insufficient evidence.

Historical Context – Time as an Element in Analysis

Williams (1961, as cited in Goodson, 1994) describes some of the difficulties in historical reconstruction that relies on document evidence:

> To some extent, the selection begins within the period itself; from the whole body of activities, certain things are selected for value and emphasis. In general this selection will reflect the organization of the period as a whole, though this does not mean that the values and emphases will later be confirmed. We see this clearly enough in the case of past periods, but we never really believe it about our own. (p. 55)

There are two cautions implied here. One is that of all the possible detail that a text could include only some is selected. This process is a reflection of the historical-context of the individuals, groups and structures that influence the selection. These documents were not created to shed light on gender issues, but rather for other purposes and therefore this selective process may not reflect or reveal how gender issues influenced document production. Secondly, the present context may affect the selection of what evidence related to the issue of gender differences in physics participation and achievement appears in my analysis. The assumptions that affect my analysis are a function of my individual (gendered) history. As well the individuals' interviewed are influenced by their own histories. They were also influenced by the historical context of the science revision time period. Therefore interviews with these individuals have a past and present context that is difficult to separate.

In case study research the context in which the case occurs is important to understanding the case and its possible relevance to other situations. In reference to historical curriculum case study research Goodson (1994) suggests that:

> It is important to stress that such study [of the written curriculum] be allied to other kinds of educational study – in particular studies of school process, of school texts, of school assessment and of the history of pedagogy. This must be grounded within an understanding of the general social and economic history of the times, as the current salience of 'markets', privatization and globalization indicates, for schooling is comprised of the interlinked matrix of these elements and, indeed, other vital ingredients. (p. 19)

Chapter 4 (The Context) includes information on the Alberta educational context and a review of studies directly related to this science curriculum revision. This chapter reveals

some of the context Goodson refers to.

My Historical-Social Context

My research reflects the historical-social context in which I am situated at a particular time, place and location – secondary education at the University of Alberta. My interpretation of my experiences in educational contexts and the experiences of others - particularly as evidenced in research - is influenced by the individualized history and broader social history that I am a part of.

A science education at university prior to becoming a teacher prepared me for an understanding and dedication to a particular philosophy of science. I thought in terms of problems, hypotheses, evidence and skepticism. Theories cannot be proven - only falsified. Truth is elusive – but objective. In my first few years of teaching I tried to create what I felt was science in my classroom. I was heavily influenced by experimental processes and my classes reflected this orientation. When the curriculum for science changed in Alberta it affected my understanding of science. STS – I don't recall the original philosophy of this curriculum but I do recall the uproar. I attended a meeting related to the curriculum revision where the theme seemed to be 'Don't fix what isn't broken'. Resistance to curriculum reform - when I read Blades' (1997) metaphor of curriculum revision I was able to identify my own actions illustrated within the context of his text. The STS version of the curriculum was a challenge but I collaborated with others to approach this new science discourse in my teaching. However, I started to question my philosophy of science – I tried to compartmentalize questions created about the nature of science knowledge into the 'applications of science' to leave the 'philosophy of science' unscathed and I was somewhat successful.

On reflection my parallel gendered history began to influence my teaching more noticeably at this time as well. In the early 90s some female students started responding differently to my classes than before – they were more assertive and opinionated. I start to insert 'feminism' into my teaching – not by design but subconsciously. I have daughters, I have experienced gender - differentiated treatment and it revealed itself in my dialogue with students and in the societal contexts of the classes I taught. The STS curriculum emphasis had given me 'space' to include context that related to social issues

and my own personal history had given that context a particular form.

Lately, I have read about the promise of science curricula transformation to reflect 'feminist science' as described by Harding (1986), Keller (1983) and other feminists. These feminist theorists were not familiar to me earlier in my teaching career. I was familiar with a background of affirmative action, equal opportunity and the feminist theorizing period that Gaskell (1993) describes as "make girls like boys". It appears that the context – place and time – in which I worked subconsciously influenced my theories and beliefs about science education. It also seemed to affect the relationship of female students to the science curriculum that they experienced.

As stated in Chapter 1 (Locating the Research), in 1996 I began work as a seconded teacher for Alberta Education in a job where I had access to data, as an examination manager, that created new questions for me about education, assessment and what it is to 'know' in science. Many of these questions related to the assessment process and how it selected 'how and what' knowledge was expressed in ways that might be advantageous or disadvantageous to specific identifiable groups of students. In 1999 I began a part-time Masters degree with the intent of investigating some of these interesting questions. I read a variety of research designed to investigate gender differences in science achievement and found a variety of approaches, assumptions and conclusions that were often contradictory. In the background literature I presented some of this research.

I find that my orientation to gender issues fluctuates between feminist social-critical interpretations and post-modern interpretations (particularly Foucault's analysis of power-knowledge). Since these two types of orientation influence research methods and analysis in very different ways, this created some tension for me in this research study. My readings of work by two feminists, Patti Lather (1991) and Sandra Harding (1986), seemed to indicate that they also found this a dilemma. Lather (1991) suggests shifting the focus in interpretation frameworks to an emphasis on discourse as an object of investigation rather than paradigms of thought. Analysis should avoid trying to find single-cause explanations that might guide actions but rather take advantage of a variety of possible interpretations that might open up rather than limit discussion. At the same

time she suggests that critical theory needs to be retained within this more relativist framework so that research can still uncover evidence of where one group may in various ways exert power over another to its detriment.

It seems likely that both postmodern and critical theory traditions had some influence on my interpretation of the data. I tried to be aware of my own background and reflect on how it might influence my analysis – to scrutinize interpretation for bias. My research was at least partially designed to investigate what I believed was a gender imbalance in participation in high school physics and to have some impact on that imbalance.

The Context: Curriculum Revision in Alberta: 1984-1995

A Brief Overview of Alberta's Education System

In Canada education is a provincial or territorial responsibility. Alberta has a ministry of education that oversees education. The school system is divided into elementary, junior high and senior high school divisions. At the senior high level there are three levels typically referred to as grades 10, 11 and 12. Courses that roughly correspond to these years of schooling are numbered using two digit numbers in the 10's for grade 10 (ex. Physics 10, Science 14) in the 20's for grade 11 and in the 30's for grade 12 but students can be enrolled in these courses in any of the years they attend high school as long as they have the pre-requisites. The program of studies for each of these courses is a legal document produced by the Curriculum Standards Branch of Alberta Education and signed by the Minister of Education that "outlines what teachers are **required** to teach" (Alberta Education, 1992e, p. S.1-1) They may also produce teacher resource manuals that contain "planning, teaching and evaluation strategies [that are] … **suggestions** only and are not mandated" (Alberta Education, 1992e, p. S.1-1).

There are approved text books for courses that have been reviewed by the branch or that have been developed specifically for a course. Usually there is a choice of two primary texts for a course. Other curriculum resource materials might be approved and available for a course.

Prior to 1984, the high school science programs included Physics 10, Physics 20 and Physics 30. Each of these courses was assigned "credits" – 3 each for Physics 10 and 20 and 5 for Physics 30. The number of credits is related to the minimum hours of instruction required for a course. Completion of high school in Alberta requires a minimum number of credits, minimum credits in some study areas and some required courses. In 1984 a minimum of 5 science credits was required for graduation. Physics 10, 20 or 30 were not required courses for graduation in 1984. After the revision to the high school programs a new grade 10 science course, Science 10, was developed and implemented in 1993. This general science course replaced Biology 10, Chemistry 10 and Physics 10. Physics 20 and 30 continued to be optional courses in high school. Students

are required to have a minimum of 10 credits in science.

A separate department of Alberta Education, the Student Evaluation Branch produced diploma examinations for some grade 12 subjects including Physics 30 in 1984 and continues to do so in 2003 (It is now called Learner Assessment). The final mark that a student receives in Physics 30 is a combination of 50% teacher-awarded mark and 50% diploma examination mark. The examinations are produced with the input of teachers as item writers, reviewers and markers of the written components. Gender specific data on participation and achievement in each of the diploma examination subjects is collected. Some of the data collected is available publicly and some is available only to specified levels of education authority. For example, school and classroom achievement and participation statistics including those for gender, are released to superintendents of a particular school board, who can then share those with staff members as they deem appropriate.

Curriculum Revision – Structure and Process

Science curriculum revision processes and policies across Canada are described by Connelly, Crocker and Kass (1985b) based on policy and curriculum documents available at the time. According to this study, curriculum revision in Alberta is initiated by the Planning and Evaluation division. A program analysis is used to develop policy during the revision. A variety of information is collected to help in this process. In the early 1980s, survey questionnaires were sent to high schools to determine educators' opinions on the length of science courses, the core elective format of these courses, the roles and perception about projects in science, the appropriateness of the resources and the perceived need for revision of the science courses. Following the survey process, a series of regional seminars was held based on the feedback from the questionnaires.

A document titled *Principles Guiding the Development of Alberta Science Curriculum Grades 1-12* (1979, as described in Connelly et al, 1985b) guided science curriculum revision. This document was under review in the early 1980s. It is the basis for defining goals and general objectives for the science curriculum, describes how proposed revision, research and design should occur and outlines the approval process, and specifies how content development including resource approval should occur. A

Curriculum Advisory Committee (CAC) advised the Ministry on curriculum development proposals and final program content after piloting and consulted with stakeholders on important policy issues. It consisted of the Assistant Deputy Minister, Directors of Language Services, Special Education Services, Early Childhood Services and Curriculum and contained representatives from Program Delivery, Planning and Evaluation and Finance and Administration.

The Curriculum Branch was responsible for identifying objectives, creating programs of studies, recommending texts and identifying and producing instructional materials. A Science Curriculum Coordinating Committee consisting of 8 to 10 members with a broad representation advised and helped the Curriculum Branch in several ways. They assessed provincial and societal needs with respect to science; provided direction on objectives, curriculum content and types or resources needed; evaluated the science program; examined the articulation for grades 1-12 science programs and helped with long term planning. Resources were selected based on their direct fit to the curriculum, absence of major deficiencies, Canadian content and cost effectiveness. Resources were reviewed by a specified process and field tested. They were then approved by the CAC.

Most of these general procedures were followed during the 1984-1995 science curriculum revision. However, some changes were made to committee structures and responsibilities during this period. The most significant was the formation of a new advisory body in 1989, called the Minister's Advisory Council on Science, which had a membership that included business and post-secondary representatives (Panwar and Hoddinott, 1995).

Other Influences on Alberta Education – National and International Testing

The Council of Ministers of Education, Canada (CMEC) acts as a vehicle for cooperation and coordination between provincial and territorial education authorities. These authorities often initiate projects through this vehicle. For example, CMEC initiated SAIP in 1989 to measure achievement in school subjects nationwide. This initially involved assessing 13 and 16 year olds reading, writing and mathematics, but in 1993 they included science (CMEC, 1999). Provinces and territories may or may not decide to participate in these initiatives. The CMEC also cooperates with a branch of the

federal government, Statistics Canada to collect educational statistics through the Canadian Education Statistics Council which was established in 1989.

Participation in international studies is each province's or territory's decision in Canada. TIMSS measured Physics achievement (among other things) of a sample of students enrolled in physics in their final year of schooling in 1995-96 across Canada. Alberta chose to over-sample their population in order to obtain separate provincial results from the study and contributed financially to the over-sampling costs.

Nature of Science – Historical Context

The Physics 10, 20 and 30 curriculum in Alberta in 1984 was similar to the physics courses across Canada. Roberts (1988) described seven different science curriculum emphases that he felt were historically present in North America. During the 1950s and 1960s he felt the dominant emphasis was the "*structure of science* ... [which] orients teaching in such a way that the student comes to understand how science functions as an intellectual enterprise" (p. 35). Blades (1997) described how during the 1950s and 1960s, historical events placed the location of curriculum expertise outside of the classroom as "experts in the science disciplines became school curriculum writers and advisors" (p. 19). The curriculum was perceived as "materials-in-use with authority located somewhere distant to the classroom" (p. 19). This is similar to the description of science emphasis by Roberts (1988).

In Alberta, in 1984 when the review of secondary program was initiated, it seems likely that the emphasis taken by many teachers was similar to what Roberts (1988) describes as the "structure of science". Textbooks most likely influenced many teachers' delivery of the curriculum with possible differences in emphasis depending on the textbook choice.

Curriculum Revision and Resistance: Some Related Studies

There are a number of research studies and articles related to the science curriculum revision in Alberta during 1984 to 1995 time period. Although none of these references had extensive references to gender issues, they provide perspectives and background (a historical context) to the revision process as interpreted by their authors.

These are studies by Blades (1997), Kilian-Shrum (1996), Kull-Romanyshyn (1996), and Roscoe (1993) and a journal article by Panwar and Hoddinott (1995). All of these authors were directly involved in some aspect of the science curriculum revision providing an insiders view of the process from various perspectives.

All five of these sources describe a STS emphasis during this science curriculum revision in Alberta. A study by the Science Council of Canada (1984) titled *Science for Every Student: Educating Canadians for Tomorrow's World* was described as a major influence in developing this focus. Each describes some form of resistance to this change although the focus of the studies differs and the interpretation of the degree of resistance and its relative effect on desirable science reform varied considerably. Gender issues are not described as a major focus of the curriculum reform by any of these authors but each mentions gender issues in some aspect of the curriculum revision.

The STS emphasis was promoted in Canada by the Science Council of Canada in 1984. Although this movement was widespread across North America, as Blades describes: "The Canadian province of Alberta became the first region internationally to adopt an STS approach to all secondary school science courses in that province, non-academic and academic" (p. 38). In this way Alberta was breaking new ground in their attempts to integrate an STS emphasis into the secondary science programs of study.

Roberts (1988) analyzed a series of transcripts of participants at a deliberative conference in Alberta in 1983 on science curriculum reform that was part of the Science Council of Canada study. In this analysis he explains that advisory bodies to curriculum revision do not present unified views of "what counts as science". Roberts describes what this means for a ministry like Alberta Learning: "Different stakeholders typically express strong views about different curriculum emphases, and any governmental body formulating or reformulating science curriculum policy for public education in a democracy has to take those views into account" (p. 39).

Part of the changes proposed for high school science included the development of the new Science 10, 20, and 30 programs of study, a change in credit structure and an STS emphasis for the science program. Panwar and Hoddinott (1995) felt all three changes generated resistance, particularly from the "academic scientific and engineering

community, and the senior high science teachers" (p. 508). They describe evidence of resistance to the new science programs emphasis – in the form of new committees with a much different representation from previous curriculum committees, increased scrutiny of the curriculum documents, and changes in many of the processes of curriculum revision. The formation of the Minister's Advisory Council on Science in 1989 was one example of the political response to this resistance. This committee felt that "the STS approach... had no place in a science programme" (p. 510). Despite this resistance, and largely due to the support, according to the authors, of two key individuals some of the changes were retained although somewhat diluted.

Blades (1997), also describes reactions by a diversity of individuals and groups to the new science 10, 20, 30 programs of study and their STS emphasis. However, this resistance was from a wide range of groups and individuals – not one predominant subgroup as suggested by Panwar and Hoddinott (1995). Blades' interpretation of the resistance to the new science curriculum in Alberta resonated with my own experiences, given my placement within this historical period of curriculum revision in science in Alberta as a teacher.

Killian – Shrum (1996) found that some of the teachers she surveyed and interviewed had resisted the initial vision for the curriculum because of some specific concerns about the new curricula that were related to the practical difficulties of dealing with the change. Some teachers were worried about their lack of expertise in all three sciences and how that would affect their ability to teach an integrated grade 10 science course with an STS emphasis. Practical as well as philosophical concerns seem to influence the acceptance of curriculum revision.

Krull-Romanshyn (1996) characterized the functional paradigms of the individual members of the science curriculum team as "evolving" during the curriculum revision process. Some educational theorists suggest that the unconscious social-historical context that shapes an individual's sub-conscious thoughts, rather than the stated beliefs or functional paradigms of an individual, influences many of the actions an individual takes on a day to day basis (Davis, Sumara and Luce-Kapler, 2000). The resistance to the science curriculum revision may have unconsciously shifted these individuals' paradigms

throughout the revision process.

The reasons for the resistance to the initial vision for high school science curriculum revision in Alberta during this time period are probably multiple.

Impact of the resistance on curriculum change. Regardless of their cause, the impact was that the period from 1984 to 1989 was marked by an increasing resistance to the draft proposals made by Alberta Education. In 1989 a major reorganization of the Education department also occurred. The response of the new Minister of Education to this resistance culminated in the announcement of a set of new directives for the senior high school science programmes on January 26, 1990. Panwar and Hoddinott (1995) described four key points that were included in the 1990 decision by the Minister of Education on the new programmes. These included re-developing the Science 10-20-30 as a "rigorous" science course; a five credit rather than three credit value for each of the 20 level sciences and a commitment to inservice for implementation of the new science courses. The last commitment was in reference to the concern expressed by some stakeholders that there was a shortage of science graduates. This was stated by the authors as: "The government would ensure that more students became interested in science, especially young women. Teachers and counselors were asked to explore means to encourage more girls to take science and to consider careers in science" (p. 511).

From 1990 until 1994 these new directives would have influenced the final program of studies produced in Physics 20-30. This suggests part of the official government response to a shortage of science graduates might be to encourage increased participation of girls in science careers.

Gender issues reflected in these curriculum revision studies. According to Panwar and Hoddinott (1995), concern that the number of science graduates in Alberta was inadequate was common among academic scientists and scientists working in industry and engineering. In the review process that created the 1985 *Secondary Education in Alberta Policy Statement* this concern was reflected along with other concerns. They state that: "Schools and school programmes were seen to play an important role [by the Alberta government] in ensuring economic growth and developing social consensus in a multicultural society" (p. 507). How best to increase the number of

science graduates was not necessarily a point of consensus among the various groups involved in the curriculum revision process. Kilian-Shrum (1996) describes this conflict in the revision process:

> The lingering effect of the overriding goal of past curriculum reforms – to produce more scientists and engineers – continues to compete with the recent goals of preparing the very large majority of students, who will not likely use science in their careers, to lead their daily lives in an increasingly science and technology-oriented society. (p. 124)

The goals of the curriculum reform and the means to achieve those goals were areas of contention, conflict and eventual compromise. Gender issues were one of many competing issues that influenced the revision process. However, they were linked to specific science curriculum revision goals like an STS emphasis and a general Science 10 course as a means to increase the participation of girls who participated in science courses like physics and thus increase the number of potential scientists and engineers.

Gender was linked to the rationale for an STS emphasis by Krull-Romanyshyn (1996). She stated that the Science Council of Canada Report recommendation 5 - an STS emphasis- "was determined to have the greatest potential to respond, not only to recommendation 5, but to all of the other recommendations" (p. 15). This included recommendation 2 - increasing the participation of young women in science education. This inclusion suggests that gender issues may have been an underlying consideration for at least some members of the curriculum revision team. It is important to note that this goal, according to Krull-Romanyshyn, was not formally articulated. She summarized the field validation teachers' anticipation of the positive effects of the changes on students as:

> A great majority of teachers ... cited greater opportunities to learn higher order thinking/problem-solving skills in practical and relevant contexts, more excitement, interest and personal involvement in science, greater enjoyment and appreciation of science and even increased interest in career opportunities in the science area. (p. 97)

Presumably female and male student would be included in this anticipation of positive effects of the new science courses.

Killian-Shrum (1996) described some limited evidence that a general Science 10 course was believed to have increased the participation of girls in Physics 20:

> Previously, students had to choose if they wished to specialize in a particular science discipline when they were in grade 8, a time when they were less mature and knowledgeable of the sciences. In Colin's school, the new structure resulted in more students, particularly girls, opting for Physics 20. In my position as curriculum consultant at Alberta Education I had heard of several other schools in which this was the case. (p. 81)

There seemed to be at least a perception that the change in decision-making time was instrumental in increasing the participation of girls in physics courses. The data on participation by gender indicates that the percentage of girls as compared to boys enrolled in Physics 30 in Alberta did not increase after the implementation of the new Science 10 and *Physics 20-30 Program of Studies*. The perception that the change was particularly positive for girls may have been a reflection of a change that was restricted to individual classes within the province and not a wide-spread change in enrollment patterns.

Late in the curriculum revision process, awareness of gender issues may have influenced one other response to the resistance, the plan to provide inservice for teachers on the new science curriculum. The final decisions by the Minister of Education described in the article by Panwar and Hoddinott (1995) suggests the inservice project was a response to resistance and controversy associated with the new science curricula. The inservice project involved producing the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e). The chapters were written by teachers that were also involved in the inservice workshops. The resource manual contained a chapter titled "Teaching with Gender Balance". However, the workshops developed for teachers (one session of four days for each of the three years of the field validation) did not include this chapter topic directly.

Summary

The five studies referenced in this chapter help to identify the context of curriculum revision in Alberta from 1984 to 1994. In interpreting data related to the questions posed by this study I will draw on this context. Although this was not the focus of the studies, some discourse related to gender differences was described. The dominant curriculum emphasis of the curriculum revision was clearly STS but this emphasis was contested and other emphases were also important in the curriculum revision process.

The political priorities also appear to have been influenced by the conflict surrounding this revision. The conflict and compromise that arose in the context of the revision might be relevant to *conditions that support the translation of documented concerns into actions and conditions that contribute to inaction on some recommendations.* This is part of the historical-social context in which this revision occurred. The individual interpretations of the process of curriculum revision made by the authors of these studies also provide a type of secondary mirror with which to compare the individual responses of the individuals interviewed for this study.

The Evidence: Discourse on Gender Issues

The first evidence I looked for in the *Physics 20-30 Program of Studies* and related documents was related to the sub-question:

What was the publicly documented discourse of concern surrounding gender differences in physics participation and achievement at Alberta Education during a period of physics curriculum revision from 1984 to 1994?

Within some of the documents that I reviewed I found references to gender issues that indirectly or directly implied a discourse within Alberta Education during the revision process. Other documents did not directly refer to gender but were connected to gender issues by their relationship to other documents or to recommendations in these documents. Evidence of the extent of discourse and the issues expressed most often related to gender differences are included in this chapter.

Document Evidence

Curriculum documents. There were no direct references to gender within the *Physics 20-30 Program of Studies* (Alberta Learning, 1998). However, *The Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) produced for the revision contains one chapter titled "Teaching with a Gender Balance". As described in Chapter 3 (The Method), three documents were referred to as major influences on the science curriculum revision in the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) in a subsection titled "Background to the Senior High Science Program". The Government of Alberta policy paper, *Secondary Education in Alberta* (1985); the Science Council of Canada Report, *Science for Every Student* (1984); and the American Association for the Advancement of Science report, *Science for All Americans* (1989). Other documents were less directly related to the *Physics 20-30 Program of Studies*, but still connected in some way to this revision.

Figure 6 illustrates the relationship of the documents to the *Physics 20-30 Program of Studies* document.

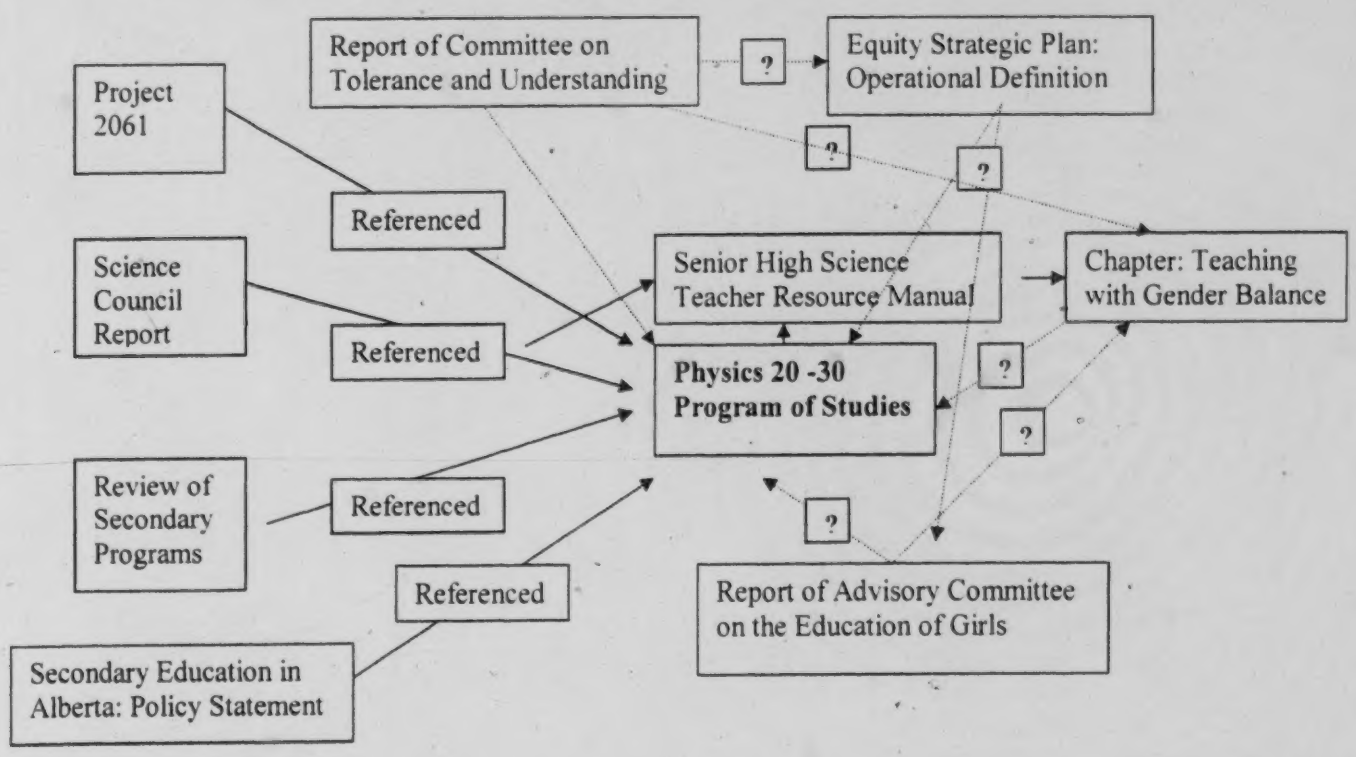


Figure 6: Relationships between documents and the Physics 20-30 Program of Studies

Curriculum documents: Connections. The document *Science for Every Student: Educating Canadians for Tomorrow's World* makes recommendations for Canadian science education based on a study of science teaching across Canada by the Science Council of Canada (1984). This study was discussed and the recommendations in it were debated in Alberta at a conference in Red Deer on May 16-17 (Nay, 1983). Seven Alberta Education representatives attended the conference. In 1987 a follow up on the impact of the recommendations of this report across Canada was prepared for the Science Council of Canada by Orpwood Associates titled *Science Education in Canada, 1987: Science for Every Student + 3 years*. In this study individuals from Alberta Education and other individuals associated with science curriculum revision were interviewed about the impact of the report on curriculum policy in Alberta in the three years following the report's release. This is significant because it includes evidence of the re-discourse of the recommendations and the acknowledgement of perceived action or inaction in Alberta on those recommendations. Several Alberta Education staff persons were interviewed along with two university representatives that had connections to the Science Council review and to Alberta's science curriculum revision. Clearly this document was part of the discourse surrounding the science curriculum revision. In the document it states that there are "eight major initiatives that are urgently required for the renewal of science education" (p. 11). One of these eight initiatives was "increasing the participation of young women in science education" (p. 11). Each of the eight initiatives had recommendations attached to it. Some of these initiatives were directed at ministries of education.

Science for All Americans (1989) by the American Association for the Advancement of Science also contains several references to gender issues. In the recommendations section of the document there is a reference to the need for science revisions to address the needs of all students including girls. Although they suggest that this is partially the responsibility of teachers, they also recommend that the science curriculum and learning materials need to reflect the actions they recommend.

Policy documents. In the first volume of the background study for the Science Council of Canada report titled, *Introduction and Curriculum Analyses* (Orpwood and Souque, 1984) it states that in the review of provincial science curriculum policy documents across Canada the researchers found that:

> No guideline at any level made any statements concerning the needs of both girls and boys. Apparently, the ministry policy statements do not generally consider these important. Whether or not they are important is clearly a matter of deliberation for each province. (p. 76)

There are no policy statements directly related to gender issues in the documents associated with the science curriculum revision that I reviewed including the *Review of Secondary Programs* (Alberta Education, 1984e); *Secondary Education in Alberta: Policy Statement* (Government of Alberta, 1985); *Proposed Directions for Senior High School Programs and Graduation Requirements* and supporting background documents (Alberta Education, 1987b, c, d) and the *Physics 20-30 Program of Studies* (Alberta Learning,1998). However there are reports of studies initiated by the Ministry of Education in Alberta and recommendations arising from those studies that deal directly with gender issues in science.

Three reports initiated by the government had direct references to the educational needs of girls. One was the *Final Report* from the Alberta Committee on Tolerance and Understanding (1984b) that was submitted to the Minister of Education on December 15, 1984. This committee was initiated by the Premier of Alberta in response to "the Government of Alberta's deep concern that a certified teacher in one of our public schools had been able to transmit, over an extended period of time, views that were clearly racially and religiously prejudiced" (p. 7). One of the tasks of the committee was to supervise "an audit of programs of studies, curriculum guides, textbooks and other learning resources" (p. 15) in use in Alberta high schools. This review was initiated by the Premier of Alberta (Peter Lougheed) "to ascertain if there are any practical changes which could be made to foster greater tolerance and respect for minority groups in our society" (p. 68, Peter Lougheed quoted). Staff from Alberta Education conducted the curriculum audit. This document would be familiar to all the staff involved in the audit – including those in science. Sex is listed as one of the five categories of minorities that the

review would consider.

Two reports and a final summary report were prepared by Harvey Social Research Ltd. (1985a, b, c) for the Deputy Minister's Advisory Committee on the Education of Girls. The two reports are titled *Factors that Differentially Affect the Schooling of Females and Males* and *Intervention Programs to Meet the Needs of School – Aged Females*. These two documents do not make recommendations. The first reviews the research literature on gender differences in education. The second reviews programs initiated by educational authorities across Canada and internationally to address issues raised by gender differences in education. In this document several programs that might be relevant to the Alberta science curriculum were reviewed. The final report contains the findings of both of these reports.

Public input – Students, teachers and general public. Input of students, teachers and the public was collected as part of the secondary program review in Alberta. Two documents reported on surveys conducted for the Alberta Government in 1984. *Opinions of Secondary School Students Regarding Objectives of Secondary Education in Alberta*: *Alberta Education Secondary Programs Review: Executive Summary* (Tolman, 1984) contains no references to gender issues. The Tolman report was based on a survey that asked students to rate goals of education that the survey company constructed. Gender issues are not addressed within these objectives so that there is no place for students to indicate that they might have concerns about the lack of science role models for young women. *The Response of Albertans to Secondary Program Review Questionnaire* (McEwan, 1984) also contained no direct references to gender issues. This survey included parents, students, teachers and non-parents. Again questions about gender issues were not included in the survey so public opinion on the issues was not sought out. Since these surveys were used as planning documents for the secondary program review, the absence of this information during initial planning for science curriculum revision is unfortunate.

In contrast, the document titled *Achieving the Vision: 1992 Report* (Alberta Education, 1993a) summarized the input of six focus groups each consisting of eight to ten 12 to 15 year-old students. It described one of two important findings as: "The

students also concluded that there is still a lack of science role models for young women" (p.59). Soliciting students' opinions related to gender issues seems to have taken place late in the science revision process.

Another student focus group was described by individual #3 during his interview. The student focus group and two "women in science" focus group meetings were organized to seek input on the Physics 20-30 Program of Studies revision. The women in science groups included women who were in some way involved in science as a career and the students were graduates of Physics 30. The women in science groups provided some insight into classroom conditions they had experienced as females. They did not express concerns about the content of the existing physics curriculum. Females in the high school focus group expressed a similar opinion about the content of the physics curriculum. As individual #3 reflected in reference to consultation with the women in science group and student focus discussions "it in hindsight was the wrong group because they had survived the gauntlet. ... frankly my expectation was that I would have got some feedback supporting the perception that girls are not getting what they supposed to out of physics and it didn't happen". Individual #3 felt that females that hadn't participated in physics in high school or post-secondary might have been another source of valuable information.

Other sources of information about student opinion were available during the revision process. The *1988 High School Graduate Survey* (Alberta Advanced Education, 1989) contained information about gender differences in career interests that might have been useful to science curriculum revision plans.

Recalling Discourse

The four individuals I interviewed varied in their recollection of the extent and nature of the discourse on gender issues in general. Individual #1 recalled discussing gender issues within the Advisory Committee to the Minister of Education, chaired by then Minister Jim Dinning, and within science curriculum revision meetings. Individual #2 did not feel that there was much formal discussion on gender issues organized by committees or staff at Alberta Education. Individual #3 felt that the issues related to gender differences in science, particularly differences in participation in physics, were

discussed by members of the science team but were usually present in the background rather than as a focus of curriculum revision. Individual #4 recalled that the science team discussed gender issues – particularly the low participation of girls in physics on many occasions.

Participation as an Issue

Differences in the participation of girls in science courses, particularly physics, emerged as an issue during the science curriculum revision. There was some difference of opinion on how important this issue was during the revision. Many source documents have pointed references to this issue, others refer to the issue in some cases as contentious and as stated earlier policy documents do not have any reference to the issue. The individuals interviewed varied in their perception of the importance of this issue to the science curriculum revision. References to data and research were important to the understanding of this issue for some individuals. There was evidence that for some the perception of the importance of this issue changed during the revision process after they became aware of data and/or research related to the issue. In other cases, personal experiences increased the individual's interest in the issue. There was also evidence that a perception of this issue existed because of a wider discourse on the issue that they were familiar with.

In individual #4's opinion encouraging girls in science was "one of the major pillars of the program". She felt that starting at the very beginning of the revision process this was presented by the program leaders as a goal of the program. A variety of different individuals of both genders – staff members, contract workers and committee members were interested in gender issues and brought them up in connection with the program revision. She described how this interest was used to maintain gender issues as one of the priorities of the revision. Individual #1 also indicated that the low participation of girls in physics was a concern. In contrast, individual #3 described participation differences in physics as one of the issues that was occasionally addressed in the revision process:

> In general terms the topic [gender differences in participation and achievement in secondary science] was always there. There wasn't a specific focus on it other than that – well in physics it got to be an issue because of the obvious discrepancy as far as participation was concerned. There were a few instances where it was

brought to the fore.

The reasons that gender differences in participation in physics were an issue varied. Document and interview evidence suggested several possible rationales for a desire to take action on gender differences in participation in physics (or science in general).

Endorsement of the issue and reasons for support. Increasing the number of females participating in science was linked to discussion about the needs of the Canadian economy for more individuals trained in science and technology in documents produced by Alberta Education and by individuals involved in the science revision. Other rationales included increasing the status of women, creating enhanced economic and employment opportunities for women, influencing the practice and interpretation of science and technology research and creating a more scientifically literate population.

In the chapter in the *Senior High Teacher Resource Manual* (Alberta Education,1992e) "Teaching with a Gender Balance", action on gender differences in participation in science courses is urged by referring to several pieces of data. Four justifications for the actions on gender differences in science participation, particularly in physics, were linked to the data: increased status for females, increased potential income for females, involvement of more females in science-related decisions and increased employment opportunities for females.

The Science Council of Canada (1984) report strongly endorsed action on gender differences in participation in physical science courses. In describing the strategies for implementation of their recommendations the report states that: "Ministries should outline, in all policy documents relating to science and technology education, concrete steps to increase the participation of girls in science and technology education" (p. 48). The text suggests that education policy reflect in writing a priority for increasing the participation of girls in science courses, like physics, in order to increase their ability to participate in science and technology careers, to benefit both themselves and society.

An economic rationale for concern about low participation of females in physics was supported by individual #1 and #4. The business and industry community felt that Alberta needed more individuals educated in science and technology to stimulate economic growth. Stimulating more interest in science in high school might increase the

number of individuals who went on to get further training in science and technology. Encouraging more females to take physics would be one way to increase the potential labour pool in science and technology fields. This economic concern stimulated interest in issues related to low participation of females in physics. As individual #1 described this:

> The second part was if we were going to increase the numbers – where were the numbers going to come from? It was pretty evident at that time and it had been for some time that gender was an issue. We did not have balanced representation in subjects like biology or for that matter physics. We needed more folks in the area of physical sciences and engineering perhaps and therefore we needed to start targeting our younger women and encourage them to take programs like physics in particular. That got the debate rolling on a number of issues.

Science for All Americans (1989) contains a general recommendation to address the needs of all students for increased scientific literacy "in particular, the recommendations pertain to those who in the past have largely been bypassed in science and mathematics education: ethnic and language minorities and girls" (p.20).

Promoting discussion of the issue – public discourse. Several documents generally encourage participation of girls in science courses and careers by promoting the issue as a discussion topic for the wider community of the school. In a section of the document, *Achieving the Vision: 1991 Report* (Alberta Education, 1992a) titled "Excellence in Science" the low participation of girls in physics is discussed. Included with this document is a pamphlet titled *Achieving the Vision 1991 Report: Users' Guide* (Alberta Education, 1992b). This pamphlet includes a section titled "Some questions to focus discussion on the 1991 report" that is provided for discussing the report "in your community". One set of questions is: "What's being done by your schools and school system to improve students' results in science? Are students helped to understand the importance/relevance of science? Are young women encouraged to pursue science fields?" (p.4)

The document *Achieving the Vision: 1992 Report* (Alberta Education, 1993a) also encourages discussion on gender differences in participation. Two documents produced by Alberta Education suggest that gender differences in science participation are issues that merit discussion within the community of a school and school district. Discourse on

gender issues is promoted and the idea that women should be actively encouraged to participate in science courses supported.

Another document that generally encourages participation of girls in all courses, including science is titled *Promoting Tolerance, Understanding and Respect for Diversity: A Monograph for Teachers* (Alberta Education, 1985b). This document contains "A checklist for teachers" and "A checklist for schools". The checklists are a series of reflective questions designed to stimulate discourse on how well teachers and schools support tolerance and understanding. A sample question from the school checklist illustrates this: "Do classes tend to be segregated as a result of streaming, student course selection or school counseling?" (p. 36). The text encourages discourse on unequal participation in courses of identifiable groups such as females. Encouraging this discourse implies action in response to that discourse.

Ambiguous evidence – Participation downplayed as an issue. The *Proceedings of the Deliberative Conference on Science Education in Alberta* (Nay, 1983) reported on the discussion surrounding the recommendations made by Science Council. Discussion on recommendations related to female participation in science "suggested that many people did not fully accept the situation of the female sex in science as a discriminatory one... some participants seemed to reflect difficulty in accepting the possibility of unequal and unfair treatment of females in science classrooms" (p.35). This uncertainty might have been a reflection of the relatively low rating in Canada as a whole of the importance of this objective as reported in *Volume II: Statistical Database for Canadian Science Education*, (Orpwood and Alam, 1984) the second of three volumes in the background study to the Science Council of Canada report. One aspect of the study was a survey of Canadian high school science teachers on the relative ranking of various issues in education. Although the percentage of teachers who thought this was an important objective is high (82.3 % for female teachers and 71.6 % for male teachers), it was ranked only 11th out of 14 objectives in importance to senior high science teachers. The authors' interpretation in reference to this objective at all levels of science education was that "its relatively low ranking at all levels perhaps reflects a relatively low level of awareness among teachers about the need to encourage girls to study science" (p. 55).

There was also some evidence from the interviews that gender differences in participation was not perceived as an issue by everyone involved in this science revision. Individual #2 felt that there was "very little, very little" formal discussion on gender issues organized by committees or staff at Alberta Education. In his opinion, the reason that an under-representation of girls in physics classes may not have been an issue in the various branches involved in curriculum revision may have been its relatively weak effect on limiting girls' career choices. Career limitations from an absence of Physics 30 were limited to Engineering degrees at the beginning of the time period. This resulted in more emphasis in the discussion on girls' under-representation in mathematics as a possible block to careers in science. However, during the interview he indicated that this situation changed in the early stages of the curriculum revision process when faculties such as Medicine started to require all three sciences.

Most of the evidence supports the interpretation that gender differences in participation was a relatively important part of discourse that occurred during the science curriculum revision from 1984 to 1995 in Alberta .

Achievement Differences as an Issue

In contrast to participation differences, achievement differences in physics did not appear to be an issue that was discussed to a large extent during the science revision. However, there was some discussion of gender differences in achievement in a few documents and it was described as a topic of discussion during the science curriculum revision in some of the interviews. For example, individual #4 recalled that gender differences in achievement were presented and discussed. Compared to the United States she felt that Alberta's gender differences in achievement weren't that bad but they were still an issue. A portion of this discussion follows:

> The problem was physics - that that's where we had to increase the girls [achievement]. Student Evaluation [presented information on gender differences in achievement: data on] the world, the North American data and the Canadian data. Then Student Evaluation people would talk about Alberta. And you know maybe we weren't doing that bad – we were better than the States but we still had a long way to go.

Any gender differences in achievement appear to have been less of an issue than gender

differences in participation in this discussion partially because the differences were not perceived to be as great.

The only other extensive reference to gender differences in achievement was by Individual #2. He recalled that the data on gender differences in achievement on Diploma Examinations wasn't readily available until about 1988 which reduced the availability of information for discussion about gender differences in achievement. This limited discussion on this issue prior to that data although there was some discussion after it was available. The first available gender disaggregated data came from international tests. He felt that the data from SISS, a large scale international assessment, may have been used to legitimize or encourage the collection and reporting of gender specific data on achievement on the provincial examinations. After the data was available, he recalled that discussions on gender differences in achievement were largely focused on Social Studies courses where there were the greatest gender differences in achievement on the diploma examinations rather than on science courses.

Only one document I reviewed suggested that gender differences in achievement were an issue. *Context for Learning Science Mathematics Geography: IAEP Alberta Report. The International Assessment of Education Progress II* (Belyk, 1992) a report for the Student Evaluation branch of Alberta Education, describes information about achievement and attitudes of 13-year-old Alberta students obtained from the IAEP study. Alberta students' achievement on various subsections of the test that was part of the IAEP study is provided by gender. In Physical Sciences the percentage of correct answers for males was 74 and for females was 68. In the analysis of these achievement differences the report states:

> In Alberta, boys scored on average four percentage points higher than girls. An exception to this trend is found in the results for Nature of Science. But for Alberta and Manitoba (French), all Canadian populations show girls scoring equal to or higher than boys in this content area. Similar results are evident in 13 of the participating countries. These results demonstrate that gaps continue to exist between male and female performance levels in spite of the special attention afforded this issue over the years. (p.11)

The final statement implies that action on gender differences in science achievement have been taken in Alberta. However, there was no mention in any other document I reviewed

of this issue in the senior high curriculum review process. A gender difference in participation in science was the only issue directly addressed in these documents. There is also a section that describes the findings related to gender differences. In this section it states "Obviously gender differences continue to exist in science. Performance levels show that females continue to perform at lower levels than males" (p.8). It is interesting that on two different pages the document implies that there is a gender difference in achievement in science that is consistent over time. There is no evidence given to support this interpretation. Data from Alberta provincial achievement and diploma examinations from the same time period does not support this analysis. Some mention of this contradiction might have sent a different message about gender differences in achievement to readers of the text. The subtext of this report seems to imply that gender differences in achievement cannot be changed.

Gender differences in science achievement are downplayed as an issue by the Science Council of Canada report (1984):

> Some people maintain that there are genetic causes for the differences in intellectual orientation between boys and girls, and that these differences prevent girls from excelling at science. Although this theory is not supported by any convincing evidence, it has received ample publicity that may indeed have influenced parents and teachers. The Science Council, however, finds the theory entirely inadequate to account for the large disparity in participation rates. (p. 25)

This quote indicates that their analysis does not support biological causes for gender differences in achievement in science and also discounts gender differences in ability as a rationale for low participation of girls in physical science. Later in the report they suggest that societal or environmental reasons such as: parents' attitudes, gendered experiences and unwitting reinforcement of gender stereotypes are more likely to account for low participation rates of females in the physical sciences in Canada than biological differences.

Personal experiences of individual #3 linked girls' perceptions related to their science achievement to withdrawal from physics courses: "Our experience with girls was if they stayed in physics to the end they were achievers – they were the first to quit as soon as they had a mark below 75 or 80". Research related to girls' perceptions of low

ability in science and its link to decreased participation are quoted in the chapter on "Teaching with a Gender Balance" in the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e). The text makes several recommendations for teachers to counteract negative perceptions that female students may have about their ability to achieve in science.

There is also research in the chapter "Teaching with a Gender Balance" on boys' relatively high ability in spatial tasks compared to girls and on girls' relatively high ability in communication skills compared to boys. The text suggests that these are environmentally influenced by recommending activities to improve girls' spatial skills and boys' communication skills. Research on spatial skill and communication skill differences between males and females are also referenced in the research summary report prepared for the Deputy Minister's Advisory Committee on the Education of Girls (Harvey Social Research Ltd., 1985a). They quoted research that supported early instructional interventions to improve females' spatial skills. They also described research that suggested that some studies that found males demonstrated higher mathematical and spatial skill achievement than females had not controlled for the higher number of mathematics and physics courses the males had taken. Sex differences disappeared on two of four subtests and the spatial skill subtest when these differences were statistically controlled. The author also described research related to environmental causes for gender differences in achievement in courses, including physics.

Interview and document evidence supports the interpretation that gender differences in achievement were not considered to be as important an issue as participation. However, research presented in several documents did relate to gender differences in achievement and one document contained discourse that suggested this may have been an issue at Alberta Education during this time period.

Influences on Discourse – Research, Data and Personal Context

The wider international and national research community provided background to the historical context that influenced this Alberta science curriculum revision. In the chapter "Teaching with Gender Balance" in the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e), this wider discourse is directly visible in the

references supplied with each suggestion to teachers on how to teach with a gender balance. The Science Council Report in turn includes a review of research, including research on gender differences. The *Science for All Americans* document included research references as well. The report prepared by Harvey Social Research Ltd (1985c) summarized research on *Factors that Differentially Affect the Schooling of Females and Males* for the Deputy Minister's Advisory Committee on the Education of Girls. Although the individuals interviewed for this study did not recall this document it revealed some of the research available to Alberta Education as a whole. The inclusion of references to research in these documents indicated that an international discourse conveyed through research on gender differences in achievement and participation was available during the science curriculum revision in Alberta.

There is evidence that the science team's actions were influenced by the research. Individual #4 made reference to the impact of research documents on the curriculum revision process as something that was internalized "like osmosis". She suggested that research was very important to the work of the science committee in the statement: "[individual X] was a researcher and had that in his past and [individual Z] I think he did nothing until he hired me except research". The source or type of research presented was not clear to her. However, she did recall that the research studies by the Science Council of Canada and a US report that was most likely the Science for All Americans report, were discussed in meetings. Some of the information may have been communicated from various individuals' recollections of research that they had read or heard about and other research was more formally presented on overheads. Individual # 3 also described the impact of research in a similar way as: "we had all that information there and just by osmosis it would have affected our thinking". Reference to the impact of research documents on the curriculum revision process as something that was internalized "like osmosis" and "becomes what we believed and what we thought should happen" suggests it influenced changes in thinking among the science team members during the revision process.

Gender disaggregated data was available because Census Canada, post-secondary institutes and school authorities had collected this information. As stated earlier,

individual #2 felt that data on gender differences in achievement on diploma examinations was collected and provided in public documents after an international achievement study presented their data disaggregated by gender. If the data was not available the discourse and actions arising from inequalities revealed in that data would be restricted. This data was used to establish gender differences in participation as an issue in many of the documents reviewed.

Personal experiences may also have influenced whether participation differences were regarded as an important issue to individuals involved in the science curriculum revision. Individual #2 indicated that a personal experience that occurred prior to the curriculum revision process influenced his desire to encourage more female science teachers' involvement on science committees:

> And a superintendent told me – why do I have no girls taking physics at all compared with my math classes, including Math 31, where girls were commonly represented? And he got so angry about it that he actually went down to the principals' office and ... told him to change the time-table immediately so that girls had equal access to physics courses.

Female students could not easily take physics courses at the school where he taught because they were scheduled across from physical education classes the female students were required to take. Individual #4 also indicated that personal experiences influenced her and other individuals involved in the science curriculum revision. These experiences made gender differences in participation in physics an issue for them.

The research and data presented appeared to have influenced the perception of the importance of gender issues for some individuals involved in science curriculum revision. Krull-Romanyshyn (1996) referred to the importance of the paradigms held by members of the science team and the process of perception change during curriculum revision:

> A major influence came from the personal functional paradigms, the current and evolving beliefs and feelings regarding science teaching, held by the member of the Science Team, the lead developers of the new curriculum. The functional paradigms of these educators evolved to encompass belief and commitment in a major broadening of the conception of the teaching of science.

The interviews support this interpretation of perception change. Individual #3 hadn't perceived gender differences in enrollment in physics courses as an issue until

Alberta participation data was presented to him that conflicted with his experiences in the classroom. It hadn't seemed an issue to him "until I got there [to Alberta Education] and saw the whole picture". Individual #4 recalled that participation and achievement data by gender presented to the science team created a context for understanding other information and research. As she expressed this:

> It amazed me that before I made it a focus and looked for it – all the things that might be gender inappropriate and might not give women the same chance – that I wouldn't even have noticed until I became aware of the fact that girls weren't participating and when you became acutely aware of it and you start looking at the resources and the things that you used to do when you were teaching – I just thought – gee if I would have known this it would have been so simple to make those kinds of changes but I wasn't aware of it. So personally it was an education for me and I became very proactive in looking for those kinds of things and making sure they were addressed.

For these two individuals presentation of the data seemed to have altered their perception of the issue.

Changes in individual perception also seemed to have occurred after the curriculum revision process through the process of reflection on past actions. Some of these perception changes imply possible future changes in action by the individuals. This is suggested by statements by individual #3 such as: "it in hindsight was the wrong group" in reference to focus group composed of successful female scientists and "at the time it felt like an achievement... at this time in history I guess I'm a little embarrassed" in reference to gender equity in textbook images. The reflections of individual #1 suggest how a change in perception about the role of women in science may influence a change in action related to curriculum revision in the future in the statement "we didn't have that research then but this is certainly something that could be looked upon now".

Davis et al.(2000) suggest that changes in the subconscious are acted upon and actions in the collective feed back into the sub-conscious:

> Learning not only implies a transformation of one's own body, it entails a change in activity and hence, a transformation of the character of the collective. Learning is not a simple matter of adding onto a personal store of knowledge. It is implicated in the ways in which we act in and on the rest of the world. (p.18)

There is evidence that individual and collective perceptions did change before, during

and after the science curriculum revision in ways that were related to prior actions, both their own and others. The discourse on participation influenced the individuals involved in the curriculum revision in ways that may have contributed to translating the discourse into action.

Chapter Summary

This chapter provides evidence to answer the first sub-question posed in this research: *What was the publicly documented discourse of concern surrounding gender differences in physics participation and achievement at Alberta Education during a period of physics curriculum revision from 1984 to 1994?* Evidence exists in the documents related to this science curriculum revision and in the recollections of some of the individuals involved in the process of creating those documents, that there was a moderate discourse of concern surrounding the issue of gender differences in participation in high school physics. There is also some evidence that a small amount of discourse surrounding gender differences in achievement in high school physics also occurred.

The historical context and individual personal contexts contributed to the extent and nature of discourse recorded in the documents. Research including some of the research that was referenced in Alberta Education documents but also a wider scope of available research appears to have influenced the discourse. These documents influenced the revision process in Alberta. Data was used to establish gender differences in participation as an issue. The low priority of gender differences in achievement as an issue may be a reflection of research that suggests differences are small and of evidence of only small differences in achievement on provincial Physics 30 diploma examinations. Personal interest in gender issues and individual experiences of gender inequities contributed to the discourse related to gender differences in participation. Some evidence suggests that individual perception changes related to gender issues occurred during and after the science curriculum revision based on data provided and research discussed in the process of curriculum revision.

The Actions: Curriculum Response to Gender Issues

Emerging Themes – Discourse into Action

Implied, suggested or recommendation actions within the document discourse were used to analyze the *Physics 20-30 Program of Studies* document and related documents to address the second sub-question:

> *Was this discourse translated into specific documented 'actions' in the Physics 20-30 Program of Studies and directly related curriculum documents?*

The document analysis produced some tentative answers to this question. Semi-structured interviews of participants in the revision process helped to confirm some of these initial document findings. The individual interviews provided some evidence of the connection between discourse and some of the actions within the *Physics 20-30 Program of Studies* and related documents. The interview process also helped to elucidate the location or locations where these individuals felt action had occurred and in some cases why it didn't occur in other places.

Some of the discourse of concern appears to be directly or indirectly linked to actions in the documents. Some of the discourse of concern appears to have occurred after an action and served more as a support for that action than as a causal factor. Some of the discourse of concern does not appear to have produced a related action in the documents. To the best recall of those interviewed, several documents that did refer directly to gender issues had little or no impact on the revision process or the final *Physics 20-30 Program of Studies* and directly related documents. The location of this discourse seemed to have occurred outside of these individuals' experiences. However, these documents and the discourse represented in their texts, may have indirectly influenced the curriculum revision process.

Threads or themes in the data weave the discourse and the actions (or lack or actions) together. These themes form the evidence used to reflect on the third sub-question of this research:

> *What conditions seemed to support the translation of documented concerns into actions and what conditions contributed to inaction on some recommendations?*

The themes identified within this chapter are related to the suggested actions that arose

from the discourse in the documents. Some of these actions were acted on and some were not. The creation of an operational definition of equity by Alberta Education was an action designed to respond to equity issues including gender issues. A chapter within *The Senior High Science Teacher Resource Manual* dealt directly with gender issues and was designed as a response to research that suggests classroom conditions and teacher practice contributed to gender inequities in science achievement and by extension participation. Care was taken to examine the STS examples for 'female friendly' context in response to a major review at Alberta Education of tolerance and understanding in curricula and resources. The STS emphasis of the science programs was supported by one of the major influences on the curriculum - the Science Council of Canada report. This emphasis was supported for broad science objectives, and the added support of concern for unequal participation of girls in physics courses seemed to be strategically used when STS was heavily contested as an emphasis for the new science programs. The general, integrated Science 10 course was also heavily contested and one support for the program included the possibility that delayed choice would increase the participation of girls in physics courses. Promoting the role of women as scientists was an action suggested by several documents that influenced the creation of this document. The absence of any reference to female scientists in the *Physics 20-30 Program of Studies* may reflect that action within the curricula was not clearly the vision of the science revision committees.

The Definition of Program Equity

All actions would be influenced directly or indirectly by the operational definition of equity that guided the science curriculum revision process. In 1989 Alberta Education commissioned the Alberta Management group to develop an operational definition to guide the department. The report *Program Equity Strategic Plan: Phase I: Development of an Operational Definition* (Meanwell, Weiden and Chase,1989) states the following as the operational definition:

> Program equity is unrestricted access by all students to quality school programming consistent with their learning needs and abilities and the empowerment of all students to make informal decisions leading to the fulfillment of their educational objectives and the attainment of the goals of schooling. (p. 38)

In their discussion of the development of the operational definition the authors state: "This means that differences in opportunity, participation or outcome that may exist among comparable groups are to be acknowledged as evidence of inequalities in our education system" (p. 34). They explain that this necessitates the development of data collection measures of these outcomes for various identifiable groups of students. It is clear that they expected this operational definition to be applied to gender differences in participation and achievement by reference to an earlier statement: "Schooling in Alberta is geared primarily to the needs of white, Anglo-Saxon, male students. The programming needs of females, native Indian, French-speaking, and other groups of students must be more fairly addressed" (p. 27). This is clearly an action related to gender issues taken at Alberta Education within the science curriculum revision process time period.

This operational definition is most closely aligned with Gillborn and Youdell's (2000) "equity of outcomes", a definition that they referred to as radical in stance. If this operational definition guided action, then gender differences in participation in high school physics would be an issue that needed to be addressed by Alberta Education. However, there is no direct statement in the documents that I reviewed that refers to this equity definition. There are some parallels to the wording of the operational definition that appear in policy documents. Some of these parallels are in documents that were produced before the operational definition. These may reflect the process the authors used to create the operational definition which involved a review of the existing government policy documents. The teacher resource manual document provides the most direct support for the definition.

For example, the document *Secondary Education in Alberta: Policy Statement* (Government of Alberta,1985), describes the diverse educational needs of students and refers to equity in education in the rationale for one of the eight guiding principles for secondary education in Alberta. Several specific groups are identified: "students with exceptional educational needs ranging from the severely multi-handicapped to the gifted and talented … secondary students in French language schools, native students, students

requiring assistance to learn English, and others in special conditions" (p.9). There are parallels within this rationale to the portion of the operational definition of equity that reads "access by all students to quality school programming consistent with their learning needs and abilities" (p.38). However the intent appears to be more consistent with the concept of equity as "equality of circumstance" where the individual needs of students may not be equitably addressed because they have special needs that have not been considered or adequately addressed. References to equity in *Review of Secondary Programs: Report of the Minister's Advisory Committee: Foundation for the Future* (Alberta Education, 1984e) and *Proposed Directions for Senior High School Programs and Graduation Requirements* (Alberta Education, 1987b) also relate most directly to "equity of circumstance".

The *Physics 20 -30 Program of Studies* (Alberta Learning, 1998) program overview refers to differences in students as "These science learnings will take varying amounts of time to acquire, depending on the individual learning styles and abilities of students" (p.1). This seems to refer to the individual needs of students originally raised in other policy statements not to students in identifiable groups. It could still be interpreted by individual educators to more closely align with the operational definition - that is that modifying instruction to address equity of outcomes for an identifiable group of students, like female students, is desirable. The document enables this choice but does not promote it.

There is one reference that implies support for "equity of outcomes" in the chapter on "Teaching with a Gender Balance" in the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e): "As educators we need to become aware of prevailing social and cultural influences that may be having a negative effect on our students and work toward overcoming them" (p. S.3P-6). This appears to be the most directly related reference to the operational definition of equity produced for Alberta Education in any of the documents.

It isn't clear if this operational definition guided the science revision process. The operational definition developed for Alberta Education by the Alberta Management Group was not familiar to any of the individuals I interviewed. However, they may have

been influenced indirectly by this definition.

Each of the individuals was read the operational definition and some of the quotes related to its meaning that were referenced earlier (See Appendix C). Individual #4 suggested the most direct support for that this concept of equity influenced the science revision process. As she recalled in response to quotes from the document:

> Again it just seemed to always be there that every student has the right to reach their potential and we have to do everything we can to encourage them – you know male, female, black, white, regardless of religion... so equity was really a big deal on every level....That kind of idea definitely pervaded – I mean that was the reason we were supposed to be doing something – because there was an inequity in performance and enrollment and all of that sort of thing.

Quotes from this document also seemed to individual #3 to be philosophically in line with the work of the science team. However he did not believe that the document was used formally in any decision-making. Several reasons for this were suggested. There may have been a change in curriculum focus related to this document – something that was relatively common during the early stages of the curriculum revision. As he suggested in reference to the operational definition and quotes: "It was desirable and I think this is sort of a statement which is made often – it's what you call Motherhood and apple pie – and then you start looking at specifics in terms of timing the implementation or addressing it and you need to identify resources and allocate resources it falls apart".

In contrast, Individual #2 felt, in response to these quotes, that the concept of equity of access was generally accepted but he did not feel that unequal participation in physics was considered an issue or discussed as an issue during the curriculum revision process. The general feeling was "let the market decide", as long as access was not denied. He felt that at the time there didn't appear to be concerns about gender differences in the course choices that students were making.

It appears that a variety of operational definitions for equity were used in documents and recalled during interviews as having influence on the science revision. The variety of responses suggested that individual definitions were more likely to have influenced the work of the committee than the operational definition created for Alberta Education. As one individual suggests changing priorities may have caused the formal

equity definition to be under-utilized as a guide to the science revision process. From 1987 through 1990 Jim Dinning was the Minister of Education. In 1991 Halvár Johnson took over this cabinet position in the government of Alberta. These individuals' priorities may have differed. Participants in the secondary education policy review also suggested that personnel changes in the curriculum department disrupted the secondary revision process (Alberta Education, 1990b). The equity document may simply have been misplaced by chance as personnel changes occurred. The relative influence of individuals on the *Physics 20-30 Program of Studies* and their adherence to a particular equity definition could therefore be conditions that influenced the actions taken during revision.

Creation of a Resource – Encouraging Gender Neutral Teaching

Clearly one action taken during the curriculum revision process was the inclusion of a chapter in the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) produced for the revision titled "Teaching with a Gender Balance". In addition to the text itself, Individual #4 recalled that workshops on teaching with a gender balance were presented at Alberta Teachers Association Science Council Conference. Presentations to the teachers who field tested the new Science 10 curricula the first year also included an emphasis on gender issues with specific reference to physics. The Science Council of Canada recommendations, including the recommendation to increase the participation of girls in science, were presented to the field test teachers as major thrusts of the program. The data on gender differences was presented to support this thrust. Interview and document evidence suggest that the discourse in the Science Council report and other documents was translated into this action.

The chapter in the teacher resource links the issue of gender differences in participation in science to research and action in the following statement: "By positively incorporating knowledge gained from research into classroom practice, we can encourage more girls and boys to pursue the sciences. ...The following section provides guidelines to teachers in directing their pedagogy toward this end" (p. S.3P-6). The suggestions to teachers are bolded and backed by relevant research sources. Although the initial focus of the issue was on participation differences many of these sources refer to research on

gender differences in achievement.

Several documents that were directly related to the revision process contained discourse that appears to have influenced this action. Many of the recommendations to teachers are similar to those made in the Science Council of Canada report (1984) and this report is referenced and mentioned in several locations in the chapter so it clearly influenced the author. This report suggested three locations for action on gender differences in participation, one of which was teaching methods. The final report of the Committee for Tolerance and Understanding (1984b) also contained some recommendations that were similar to those in this chapter in the resource and may have influenced its production. *Science for All Americans* (1989) by the American Association for the Advancement of Science also contains a section of the report that deals with teaching. The text supports teachers' actions as a location for change since "this debilitating perception [that girls are not suited for science]– all too often reinforced by the environment outside the school – will persist unless teachers actively work to turn it around" (p.151).

The inclusion in the *Senior High Teacher Resource Manual* of a chapter on "Teaching with a Gender Balance" was recalled by most of the individuals interviewed as one action taken with the intent to address the issue of gender difference in participation. Individual #4 recalled that the curriculum team brainstormed possible ideas for addressing the issue of low participation of girls in physics. Some of these ideas were followed up on – particularly the inclusion of a chapter on "Teaching with a Gender Balance" in the teachers' resource manual. Individual #1 suggested that this chapter supported other actions on gender issues. Individual #3 felt that: "As the title implies there was a need to address [this] issue and it did address it and this is why it's in the teachers' resource manual". During the interview, he suggested that issues related to female participation in physics might be more effectively translated into action in the classroom than in curriculum documents.

The interview evidence supports the interpretation that individuals involved in the science curriculum revision process felt that encouraging gender balanced teaching practices was a logical and appropriate place to act on gender differences in participation.

In the deliberative conference on the Science Council report held in Alberta, the participants also seemed to endorse actions on gender differences in participation related to teaching methods: "Would it suffice if a few corrective actions are taken such as science teachers avoiding classroom practices that reinforce male stereotypes" (Nay, 1983. p.36).

Research primarily from the 1970s would have been available to the individuals involved in the first stages of the curriculum revision, the stage where a large amount of research was accessed. Implications of this research often suggested changes in classroom teaching. Since the science curriculum was not revised in the 1970s in Alberta, actions that may have taken place in other provinces across Canada in the 1970s, as suggested by Gaskell (1993) may have been implemented in the 1980s in Alberta. Phrases by individuals such as #4 in reference to research like "something that had already been proven" suggest that some of this research had been internalized during the time period prior to or at the very beginning of the curriculum revision process. The delay between some research findings and the timing of action for the science revision in Alberta may have allowed some of these findings to become part of a common background within the curriculum revision team.

Two conditions seemed to support this action. First, actions directed at teachers, such as the resource manual chapter and the workshops, were supported by research and by documents related to the science revision process. Evidence suggests the individuals involved in the science revision process were aware of this research and supported actions to influence classroom teaching. This may have been in part because enough time had elapsed for the research related to classroom practices to become familiar and internalized by these individuals. Second, at least one individual involved in the curriculum revision process seemed to feel that the classroom was a more appropriate place than the program of studies documents for actions on gender issues and would have been more likely to focus on this type of action.

Gender Neutral or Female Friendly Examples

Suggestions and recommendations from supporting documents to make examples gender neutral or "female-friendly" seemed to be somewhat reflected in the *Physics 20-*

30 Program of Studies (Alberta Learning, 1998). The program of studies includes three parallel strands: *knowledge*, *skills* and *STS connections*. The STS connections include suggested examples for teachers to make connections between science, technology and society. This is the emphasis of all the science program of studies. STS connections are described as female-friendly in several documents related to the science revision and many of these examples are found in the STS connections.

The Science Council of Canada Report (1984), the report prepared for the Deputy Minister's Advisory Committee on the Education of Girls (Harvey Social Research Ltd, 1985a, c) and the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) all refer to increasing the connections to girls' interests in the context of the science curriculum.

The suggestion in the resource manual to teachers, to "emphasize the link between science and society; include animate aspects when possible" includes several examples that could equally apply to the program of studies. For example: "Regardless of whether physical, chemical or biological principles are being taught, capitalize on the animate aspects of science – relate examples to nature and the human body" (p. S.3P-9). Several of the STS examples in the program of studies are somewhat related to nature and the human body as suggested in the *Senior High Science Teacher Resource Manual.* In the Physics 20 section of the *Physics 20-30 Program of Study* (Alberta Learning, 1998) STS examples that reflect the animate world include: "evaluating the impact that living on a space station has on quality of life" (p. 23) and "Assessing the processes in which light affects living organisms, and the use of light technology to solve practical problems: e.g., growth, vision" (p. 33). And in the Physics 30 section, an example of an STS examples that relates to the animate world is: "Investigating and reporting the affects of magnetism on the behaviour of living organisms in terms of the limitations of scientific knowledge and technology and in terms of quality of life" (p.55). However the overwhelming majority of the STS examples given relate to specific inanimate technologies that are applications of the knowledge component of the program of studies. Some of these technologies are used in medicine (human body) and there are references to societal impacts of the technologies in some cases.

One of three suggestions in the Science Council of Canada report (1984) related to the curriculum is that it be constructed so that girls can identify with it while avoiding giving "the impression that there are two versions of science, one for girls and another for boys" (p. 35). The STS technology examples in the *Physics 20-30 Program of Studies* (Alberta Learning, 1998) include many that are not stereotypical of boys' interests and might be considered of appeal to variety of students, including girls, such as: "simple household tools, elevators, escalators and ski lifts" (p. 17); "carnival rides and playground equipment" (p. 21); "potter wheel" (p.21); "pendulum clocks, metronomes" (p. 27); "ultrasound, pipe organs, wind and brass instruments" (p.29); binoculars, eyeglasses, design of green houses, solar collectors, fibre optics" (p. 33); "sunglasses, photography" (p.35); "air bags, child restraint systems, running shoes, helmets" (p. 41); "telephones, photocopiers, electrostatic air cleaners, precipitators" (p. 45); "toasters, hair dryers, light fixtures" (p. 51); "magnetic resonance imaging (MRI) and positron emission tomography (PET)" (p. 57); "[exposure of] air travelers to cosmic radiation, dental X-rays" (p. 67); "street lights, signs" (p. 69) and "electron microscopes, computers" (p. 69). There are still examples that might be expected to appeal more to boys – especially in the unit on Newton's laws which uses car crashes in many examples. However, there is a fairly wide range of interests represented in the technologies used as examples that teachers could choose from in their teaching.

The Curriculum Audit Report: Volume 1 (Alberta Education,1984b) described the criteria used to evaluate the program or studies and resources and the findings for each criteria in each subject area. The report recommended "that curriculum committees be made aware of the findings of the curriculum audit and be required to use the tolerance and understanding criteria in current and future curriculum development and learning resource selection procedures" (p. 76). Although all of the science program of studies and textbooks were rated as acceptable by the task force review, there were some indications that change was needed in the future. The interview evidence indicated that this review played an important role in increasing scrutiny of the *Physics 20-30 Program of Studies*, to ensure girls' interests were included in the examples.

Individual #1 recalled that all programs of study and teaching and learning

resources were formally reviewed for tolerance and understanding and that a report related to this review was produced for each resource. He also recalled: "I think that the ones that were really given instructions [on tolerance and understanding], if I remember correctly, were the physics committees because they were almost exclusively a male club". In addition the programs of study went out to "external stakeholders to make sure girls' needs were being met". Specific groups like WISEST were consulted and they reviewed the program of studies. On one occasion, individual #1 recalled that one group consulted complained that the STS connections in the Physics program of studies were "too male-oriented" and perhaps not "gender accessible". The science team responded to this concern by arranging a meeting with the group and explaining what they were trying to do in the program of studies for Physics 20-30. This consultation allowed the team to obtain advice. Finally an individual member of the science curriculum team was given the responsibility of a final review of each program of studies to ensure it addressed females' interests. Individuals #3 and #4 also recalled specific instances where the examples used were scrutinized to avoid choosing examples that reflected and reinforced male stereotypes and experiences.

Individual #2 recalled that care was taken to examine the STS contexts for possible gender bias in the documents he was involved in producing. However, he felt that this was not a formal requirement but rather resulted from professional awareness of the issue. He felt that if a "formal political correctness approach" was used it "might have backfired". Specific strategies used were to include males and females in working groups and to present information about the issue to committee members. Margaret Anne Armour was suggested as a positive influence in creating an awareness to support this action.

Three conditions seem to have supported this action. First, it appears that the formal tolerance and understanding review, combined with scrutiny by specific committee members and reviews of the curricula by other groups interested in gender issues contributed to this action. Second, several individuals and groups influenced directly the translation of this action. Third, the direct recommendation to provide gender friendly context from the Science Council of Canada report (and within the teacher

resource that was produced in conjunction with the program of studies) was also a condition that may have contributed to this action.

STS and Girl's Interest in Science

The Science Council of Canada Report (1984) suggested that an STS emphasis might be "more attractive to girls because it will stress its human aspects – that science is an activity involving people and affecting people in their daily lives." (p. 35). The teacher resource manual describes a direct connection between this suggestion for increasing female interest in science and the new high school science curricula as: "The STS connection in the new science curriculum for Alberta provides opportunities for pointing out the relevancy of science to students' lives" (Alberta Education, 1992e, p. S.3P-9). However, the inclusion of an STS emphasis in science curricula was recommended in the Science Council of Canada report (1984) and the teacher resource manual as an important action for *all* students to increase scientific literacy. The background chapter of the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) supports the use of the STS emphasis in the science curricula in Alberta as "one of the central recommendations of the [Science Council of Canada] report" (p. S.1-4). Later in the teacher manual it states that "the aim of the STS approach is to provide the students of Alberta with a more balanced science education, an aim that has the support of educators across Canada and around the world" (p. S.1-4). Support for the STS emphasis is linked to a credible source and to a wide base of educators around the world. In Chapter 4 (The Background) the general support for the STS emphasis was described as international. Gender issues may have been just an additional source of support for this initiative.

Interview evidence supports the interpretation that the STS emphasis was supported for many reasons, only one of which was to increase the participation of girls in science courses like physics. Individual # 1 recalled that there was a belief that "STS would be a way to… encourage more young girls and boys to take science". Girls in particular were described as benefiting from this change. One reason was that "if they saw programs as more relevant to their own lives and relevant to future careers that we could encourage more young women that here was a program designed for you to take - to take courses like Physics". He felt that gender issues were used effectively to support

the goal of an STS emphasis in the curriculum:

> So in a sense the argument about gender reinforced the whole science, technology, society design scheme – mind you there were a range of other good reasons as well. This became a particularly powerful argument that we were really able to deploy to good use.

Individual #3 also implied that the focus on STS was not primarily related to gender issues when he stated that:

> [The STS emphasis] was a thing that helped to address the issue of gender differences and particularly in physics ... It was an intent of curriculum change but again the main thrust was STS – from that perspective the gender issue although it was there it wasn't a major concern and it certainly wasn't a specific focus on my part.

All of the participants interviewed recalled discussion that the STS component of the new science courses would be helpful in increasing girls' interest in physics but did not feel it was the primary reason for this change.

Gender issues appear to be linked to the decision to include a STS emphasis in the curriculum to add to support for this actions. Resistance to the STS emphasis was described by several researchers who analyzed this revision (Blades, 1997; Kilian-Shrum, 1996; Kull-Romanyshyn, 1996 and Panwar and Hoddinott, 1995). The timing of the use of gender issues to support STS in documents produced for the revision suggest that resistance to the revision may have prompted using this issue to support the emphasis. For example, the document, *Secondary Education in Alberta: Policy Statement* (Government of Alberta, 1985) describes the STS approach to be developed in science courses but does not link this to increased female participation. This is also the case in the document, *Review of Secondary Programs: Report of the Minister's Advisory Committee: Foundation for the Future* (1984e). However, in a video produced by Access Network (1991) as a teacher inservice for the new science programs, Margaret Ann Armour supports the STS emphasis in the new Science 10 course by saying that it "includes more topics relevant to girls' interests". The dates these texts were produced suggests that the relevance of the STS curriculum to female science students may have created "added value" to support the inclusion of an STS emphasis rather than acting as the primary goal of the change.

There was some evidence in the interviews that proposed actions that supported increased science participation for all students, including both males and females, were the most likely to be implemented. Many of the documents support STS as an important scientific literacy component that should be part of the education of a broad range of students. To support this action, possible positive effects on female participation in physics may have been promoted as added value. Three conditions that seemed to support this action were its perceived benefit for all students, not just female students; the broad base of support for the STS emphasis in Canada and around the world; and the added support gender issues gave to the STS emphasis when it was resisted in Alberta.

Science 10 – Replacing Specialized Science Courses

The interview participants differed in whether they believed the decision to replace grade 10 physics, biology and chemistry courses with a general Science 10 course was in response to concerns about gender differences in science participation. While some felt it may have been part of the rationale for the change – only one participant, individual #1, felt it was a primary reason for the change. He felt "one of the stronger if not the strongest rationale" for restructuring the science program was to encourage more girls to go into science, particularly physics and chemistry. The increased time before students needed to choose which individual science courses they wanted to take would give female students more exposure and confidence in science courses.

Time to decide. Individual #2 felt that the common Science 10 course might have created more opportunities for female students to make personal contact with a teacher who might help them make a decision about enrolling in physics. However, he didn't believe this was the rationale for the change to an integrated Science 10 course. In his opinion, the "rationale was that … the study of [physics and chemistry] could be more effective with ten years of mathematics complete rather than nine". Individual #4 also suggested that the delay was supported to give students more background in mathematics before taking chemistry and physics and also because "giving them a little taste of each would be good before making a decision".

Reference to the delay as support for increasing the participation of females in

science did not appear in documents until after the decision was made. For example, in the document *Proposed Directions for Senior High School Programs and Graduation Requirements* (Alberta Education, 1987b) one rationale for Science 10 was that "A general science course for all grade 10 students provides pupils with additional time to consider program options in science and to gain a more comprehensive understanding of science" (p. 12). The connection of the delay in choice of science courses for one year, to increasing girls' participation in physical sciences is made in the text of the video produced by Access Network (1991). This connection is also made in the document *Achieving the Vision: 1991 Report* (Alberta Education, 1992a) but it includes both males and females:

> The Science 10 course is designed to get more students both young men and women, interested in science and its importance to their lives. As Science 10 will give students an extra year to make career decisions, it should encourage a greater number of young men and women to explore and pursue careers in science. (p.31)

It does not appear that creating a general Science 10 course was directed only towards increasing female students' participation in physics courses. Instead the rationale that it might increase the participation of girls in physics courses appeared to add support to this action. Increasing the number of students who choose science careers was supported for economic reasons as described in Chapter 5 (The Evidence). Delaying course choice was expected to help more female students *and* male students successfully complete science courses. The economic and employment context in Alberta at the time, was a condition that supported this action.

Integrated science. The Science Council of Canada report (1984) discussed the benefits of an integrated science curriculum to promote interest in science from more students, both male and female. In their discussion they suggested that "resistance [to a more integrated curriculum] is strong from the advocates of physics, chemistry and biology as the traditional basis of scientific education" (p.16). This relationship of resistance to change based on affiliation to subject specialization is similar to the findings, discussed earlier, of Goodson (1985) in his historical study of the establishment of new subjects and Roberts (1988) findings on research on science revision in Canada in the 1980s. The resistance to an integrated program and to an STS emphasis in Alberta

during curriculum revision was also linked to subject area high school teachers and to academic specialists in subject areas by Panwar and Hoddinott (1995). Resistance to the general Science 10-20-30 program was also described by other researchers who analyzed this revision (Blades, 1997; Kilian-Shrum, 1996 and Kull-Romanyshyn, 1996).

Individual #3 felt that one of the points in support of a change to an integrated science course in grade 10 was its possible positive effect on females' participation in physics. The integrated general course would get students, including girls, "interested in knowing and doing science" and "it was one of the points that was taken in favor of the change-that it would address that issue [unequal participation] to some extent". However, he felt that in retrospect the course, as he experienced it as a teacher, was segmented into three subject area courses: "Instead of being integrated it was really three different courses being taught in the disciplines. ... Really if the course is taught as an integrated course – then we thought it was an issue that would be addressed".

An integrated science course was supported for more reasons than simply to encourage more females to take physics courses. This again appears, as was the case for the STS emphasis, to be either an additional reason for supporting this change or a reason that was used to support the decision only when it was heavily contested in public forums. Two conditions that supported this action were its applicability to more than one group of students and the additional positive support that gender issues provided for the action when it was resisted.

Increased Science Courses

The final policy for this science revision in Alberta increased the required science courses in high school by one course (from 5 credits to 10 credits). The *Proposed Directions for Senior High School Programs and Graduation Requirements* (Alberta Education, 1987b) proposed "an additional course in each of mathematics and science" (p.3) as a graduation requirement. In the review of the impact of the Science Council recommendations three years after the reports release (Orpwood Associates, 1987), the representative from the University of Alberta stated in reference to the recommendation to increase participation of girls in science:

There have been initiatives in the Ministry at the curriculum organization level

> which will increase girls' participation in Science and Math. For the High School Graduation Diploma, Math requirement is now two years (was only one), this is a potentially significant step in leaving options open to girls. Science requirements have also increased. (p. 39)

This excerpt from the interview suggests that she felt the changes in the required science courses might influence girls' participation in science. It is not clear whether she made this assessment after the change occurred or whether the curriculum revision process intentionally changed the requirements at least partially to encourage increased participation by girls. There isn't enough information to link this action to discourse on gender issues.

Women in Physics– Present or Absent?

Portrayal of female scientists in science curricula is recommended in several documents related to the science program revision. *The Senior High Science Teacher Resource Manual* (Alberta Education, 1992e) recommends teachers minimize sex-role stereotypes. To do this it is suggested that teachers "draw the class' attention to the contribution to society made by successful women in science" (p. S.3P -7). The program of studies could draw attention to these contributions as well. However out of 32 different scientists listed by name in the *Physics 20-30 Program of Studies* none are female. Why were no female scientists included in the program of studies? This is a failure by omission to follow up on one of the major recommendations of several different documents.

There was a recommendation in the *Science for all Americans* document (American Association for the Advancement of Science, 1989) that was supported indirectly by the Committee on Tolerance and Understanding (1984b), that the biases that prevented females from participating in science research historically should be part of science curricula. This could have been included as an STS connection example but it was not.

Support for the portrayal of female scientists in curriculum documents. The researchers for a background study to the Science Council of Canada report, *Volume 1: Introduction and Curriculum Analyses* (Orpwood and Souque, 1984), found in their

analysis of science textbooks used across Canada that "textbooks have slowly but surely evolved towards eliminating the crudest sex stereotypes" (p. 102). The researchers commented that a physics text reviewed portrayed almost all men in the careers section. They reflected that "on the one hand, this may represent a reality – the underrepresentation of women in science and technology. On the other hand, it leads one to wonder about the impact of implicit messages conveyed by such illustrations" (p. 102). This finding was related to the recommendation in the final report that both science curricula and texts include more representations of female scientists.

The Curriculum Audit Report (Alberta Education,1984b) described the criteria used to evaluate the program of studies and resources and the findings for each criteria in each subject area. Although all of the science program of studies and textbooks were rated as acceptable by the task force review, there were some indications that change was needed in the future. Three of the six criteria were areas where, by omission, the science program of studies were somewhat lacking. Criterion 4 was: "Do the *programs and supporting materials* [italics added] convey that excellence in human endeavour may be found in different ways in all human groups?" (p. 28). The text further states: "Recommendations were made to highlight the contributions of men and women and representative minorities in the *curriculum documents* [italics added] as several resources now do" (p. 29). This recommendation specifically addressed curriculum documents and since the curriculum review was conducted by staff from the curriculum department they would be aware of the recommendation.

Support for addressing historical bias. The more radical recommendations in the *Science for all Americans* report (American Association for the Advancement of Science, 1989) that teaching about bias and the social construction of science should include how gender bias and discrimination against women in science may have affected science in the past, including the lack of female participation, is also ignored in the program of studies. This report describes the attributes of science and scientists that the authors believe should be promoted in science education. To illustrate how students should be taught that "scientists try to identify and avoid bias" (p. 28) they describe an example of a case where they felt gender bias influenced scientists' interpretation. To illustrate how to

teach that "science is a complex social activity" (p. 29) they describe ways in which gender limited female participation in the past:

> Before the twentieth century, and well into it, women and blacks were essentially excluded from most of science by restrictions on their education and employment opportunities, the remarkable few who overcame those obstacles were even then likely to have their work belittled by the science establishment. (p. 29)

The *Curriculum Audit Report* (Alberta Education, 1984b) also indirectly supports taking action to discuss reasons for a historical absence of female researchers in physics. Criterion 5 was: "Do the *programs and supporting materials* [italics added], by omission, fail to take advantage of content or techniques that could assist the teacher in dealing positively with tolerance and understanding?" (p.30). Science was described as an area that did not address criteria 5 by omission. Criterion 6 states: "Do the *programs and supporting materials* [italics added] implicitly and explicitly convey the nature and value of critical thinking in constructing our everyday interpretations of the world and the people within it? (p. 30). The report suggests that although science program of studies do not currently address this criterion, they should do so in the future: "The importance of developing process or critical thinking skills is stressed in most of the science materials. These skills could be used to promote tolerance and understanding of minority groups and individuals" (p. 47).

Absence in history equals absence in the program of studies. In response to a question on the Science Council of Canada recommendations, Individual #1 felt that in all science programs there was a balance in the gender and ethnicity of scientists represented. When the absence of any female scientists mentioned in the *Physics 20-30 Program of Studies* was brought up he clarified that this balance was within the career theme of the text resources and not the program of studies itself. Further to a question on the number of male scientists mentioned by name in the program of studies he suggested that this might be a reflection of the "narrative of the history of science". However, he suggested that today there might be more ways to include females' roles in the history of physics as more research is available on those roles:

> I think that if you look at physics if you want to talk about certain ideas then you have to reference them back to the people who noted them but that does not mean

> – I mean we can't go back and change the narrative of the history of physics – we can talk about the reality of the times and why or why not women did not receive the kudos of the time....Well we didn't have that research then but this is certainly something that could be looked upon now.

Individual #2 also felt that if there were a "quasi-historical view of the development of physical science it would be all male" since very few female scientists could be used as examples in the context of the history of physics in the existing curriculum. This view was elaborated as a possible reason for the absence of any reference to female scientists by name in the Physics 20-30 curriculum even though there were many male scientists mentioned by name. He also felt that most of the revisions to the physics curriculum involved "rearrangement of the '84" curriculum and adding STS examples. The references to male scientists may have stayed since these names were primarily part of the existing context of historical development in the knowledge section of the document.

In reference to including women scientists in the curriculum Individual #4 recalled efforts the curriculum team made to communicate to each other any information available on women in science. This suggests that there might have been some effort to include examples of female scientists in curriculum documents but this did not extend to the *Physics 20-30 Program of Studies*.

Textbook scrutiny. Although the image of a female scientist is not promoted in the *Physics 20-30 Program of Studies*, it was recognized as an important issue in textbook resources. The primary drive behind the scrutiny of textbook images appeared to be the Committee on Tolerance and Understanding's review. The review suggested that both the curriculum documents and textbook resources should be scrutinized for adherence to the criteria developed in the review process. However, one response to the review, a formal document produced for each recommended resource, may have suggested that textbook images could support the promotion of women as scientists without the same attention to this detail in the *Physics 20-30 Program of Studies*.

All of the individuals interviewed recalled textbook scrutiny. Most cited the Committee on Tolerance and Understanding's review as an influence. For example, individual #4 recalled that the curriculum team "had tolerance and understanding screens of the textbooks – we had to count the number of girls in the pictures versus the boys and

whether the girls were in traditional sort of roles or non-traditional and are males presented as sexist and all this kind of stuff". There was a standardized form that had to be used in reviewing the recommended resources that included a check list containing categories on gender balance. She felt the science team "probably would have created some kind of a check list anyway but the program managers had to get through all the things they had to and then we would have to agree on criteria so it was probably good that they had the [tolerance and understanding] forms". A variety of checks and balances were used to ensure that the requirements of the resource review were met. The individuals interviewed recalled instances of internal review by the science curriculum team (formalized peer review in one case), review by committee members, external review and the necessity for formal documentation that tolerance and understanding criteria were met.

There is some suggestion that a tolerance and understanding review, although it seemed like a major initiative at the time, was now viewed by the individuals I interviewed as an obvious component of all resource approvals. For example, individual #1 felt that tolerance and understanding reviews are "now commonly established practices as a matter of course in resources but back then this was all pretty new stuff". In reference to balancing the gender of textbook images, Individual #3 suggested that this response to gender issues seemed small to him in retrospect although it "felt like an achievement" at the time. The perspective of time had changed his perception of the extent and effectiveness of the textbook changes. As he reflected: "at this time in history I guess I'm a little embarrassed".

Overview. The scrutiny of the resources did not extend to the textual images of female scientists in the *Physics 20-30 Program of Study*. The absence of female scientists mentioned by name in the program of study did not seem to be a topic of discussion during the curriculum revision process. Some of the individuals interviewed seemed initially surprised that there was an absence of representation of female scientists in the *Physics 20-30 Program of Studies*. It almost seems to have been an oversight in the process. In response to questions, the participants suggested various reasons for the lack of women scientists in the program of studies.

This science curriculum revision does not appear to reflect research that "rethinks knowledge, curriculum, and school structures as reflections of male power" (p.147) that Gaskell (1993) felt predominated across Canada in the 1980s. In the national context there was a reference to this issue in the document *Who Turns the Wheel* (Science Council of Canada, 1982). Reporting on specific recommendations to the BC government it states:

> Sexism guidelines should not only prohibit the more obvious kinds of sexism, but should indicate less apparent kinds of bias, often overlooked, that are as great a problem. ...the omission of women scientists in historical discussions of science... are subtle forms of bias which reinforce the view that science is man's domain. These factors may make girls feel peripheral in science classes. (p.94)

A formal guideline such as this would have increased the probability that this action was taken. The support of female physics students and women in science focus groups for the status quo (interview 3) may have reduced the urgency to carefully rethink the masculine image of scientists portrayed in the *Physics 20-30 Program of Studies*.

Conditions that supported action on the textbook images appear to be a formal review requirement, the prevalence of this action across Canada and the interest of individuals and groups in reducing visible gender stereotypes. Several conditions may have contributed to inaction on the portrayal of female scientists in the curricula. Action taken in the text resources to increase the visibility of female scientists may have served as a substitute action. The process used to address the tolerance and understanding review recommendations seemed to focus on stereotypes (particularly in texts) rather than on the more subtle criteria related to historical bias. The change required a more radical view of curricula as a site for action on gender issues than may have been familiar to individuals involved in curriculum revision. Finally those individuals who might have supported this action (as suggested by the search for examples of women in science) may have overlooked the predominance of male scientists mentioned by name in the Physics 20-30 curricula simply by chance.

Female Committee Involvement

Two individuals interviewed felt that they or the science team encouraged the

involvement of female science teachers in committees related to physics curriculum revision in Alberta. This strategy was used to reflect their perspective in the curriculum revision process. The implied assumption was that they might have more interest or insight in gender issues than male science teachers.

Individual #1 described how female science teachers were encouraged to participate on advisory and development committees. There were few female science teachers at the time and their input was consciously solicited "so that they could reflect the reality that we wished to serve" in the programs of study. Individual #2 also felt that he encouraged participation of females in committees and in other roles related to physics education. The intent of this encouragement was that this might "get them interested in recognizing that they could influence both their peers, student teachers at the university and also their students into taking math/science teaching as a career". Focus groups of students (Alberta Education, 1992a) suggested that a lack of female role models in science was perceived as an issue by high school students. Strategies to encourage females to teach physics would help to increase the number of female science role models available to students.

Disappearing Documents

Three documents that might have influenced science curriculum revision but seemed to have disappeared were prepared by Harvey Social Research Ltd. (1985 a, b, c) for the Deputy Minister's Advisory Committee on the Education of Girls. (This may have been the task force referred to by the University of Alberta representative in the Science Council of Canada follow up study.) The operational definition of equity developed for Alberta Education by Meanwell et al. (1989) as described earlier was also unfamiliar to the individuals interviewed for this research.

The report titled *Intervention Programs to Meet the Needs of School-Aged Females* (Harvey Social Research Ltd, 1985b) describes interventions to delay subject choice in science and technology as an intervention that increases girls' participation in those courses. In this document several programs that might be relevant to the Alberta science curriculum were reviewed. Many provinces and countries were cited as having undertaken text reviews for sexist stereotypes. The document also reported on the

Ministry of Education in British Columbia's action plan for 1984/85 which included:

> alerting curriculum committees to the need to address female/male preference in terms of learning styles, content focus and content presentation throughout the curriculum development process. These preferences should be addressed in the curriculum as well as the learning resources recommended to support it. (p. 12)

This suggests curriculum as a site for action on gender issues.

The timeline for the science curriculum revision indicates that there was a change in the Minister of Education during the period of time when these documents were first made available. The document *Proceedings Minister's Forum on Secondary Education Policy Implementation* (Alberta Education, 1990b) suggested that staff changes had contributed to poor implementation of the secondary curriculum revision:

> Fallout from Alberta Education's reorganization also hampered curriculum development and implementation. It caused some disruption in work flow, diminished the pool of curriculum experience and expertise, put some projects on hold, and left fewer people to do the work. (p. 21)

This same document suggested another reason that implementation of the policy may have been negatively impacted as:

> The concern here was that despite the best laid plans for education, unanticipated events can alter effort toward a goal. In some cases this may not be bad. In others it is counterproductive. But generally speaking such events can't be ignored because they do have an impact on education and the implementation of curriculum changes. (p. 28)

Some recommendations and documents may not have been utilized in the final *Physics 20-30 Program of Studies* because of changes in political priorities, staff changes and/or reductions and chance "unanticipated events".

Discourse to Action – Possible Routes

There were specific documented actions taken within the *Physics 20-30 Program of Studies* and related documents at least partially in response to discourse on gender issues. These actions included the creation of an operational definition of equity that could have influenced the curriculum revision process; the creation of a chapter on "Teaching with a Gender Balance" as part of a resource for science teachers; inclusion of girl-friendly examples in the STS context of the *Physics 20-30 Program of Studies*; the

STS context of the program of studies; and the creation of a general Science 10 course to replace the specialized grade 10 science courses. One action that was supported in the discourse was not translated into action. This was the inclusion of female scientists in the program of studies. However, there was attention to this action within the resources recommended for the high school physics courses.

Several conditions were described that supported each of the actions that were identified in the Physics 20-30 Program of Studies or directly related documents. The conditions that seemed to contribute to more than one action are listed below:

- A variety of equity definitions that appeared to operate during the science curriculum revision supported action on gender differences in participation. Individuals and groups with strong convictions related to "equity of outcomes" were most likely to have initiated reviews of STS examples to ensure they were gender friendly. These individuals and groups appeared to influence the translation of discourse into action.
- Conditions that created awareness among the science curriculum team of the wider context, national and international, related to gender differences in science participation produced conditions that supported action. This includes the availability of research documents and data particularly the resources that were directly referenced as influences in the revision process.
- Actions that appeared to be widely supported nationally and internationally, like the STS emphasis were familiar to the individuals involved and generated more support even when resistance to these changes occurred.
- Actions that could support other concerns related to science education, especially when there was resistance to change, and that supported more than one identified group of students were supported during the curriculum revision process.
- Administrative regulations related to the tolerance and understanding review that required action, directed and influenced the translation of some documented concerns.

There is evidence that suggests that these conditions influenced the translation of documented concerns into actions. There is also evidence that each was not sufficient to

ensure that a specific documented recommendation was translated into action. These conditions may support action but they do not guarantee action. Other conditions may have influenced the translation of discourse into action but there is not sufficient evidence from this study of other conditions that may have played a significant role in the translation of gender issues into actions in the *Physics 20-30 Program of Studies* and directly related documents.

Only tentative suggestions can be offered about the conditions that contributed to the failure of the *Physics 20-30 Program of Studies* to reflect any women scientists. Possible changes to the program of studies knowledge of physics component may have been overlooked in the process of review. A view of historical knowledge that did not include the concept of historical bias in female participation seems likely. Theoretical stances and research related to critiquing the nature of science knowledge may not have been as familiar to the science revision team as other research on gender differences. This research is slightly more recent than a large bulk of research on gender differences in science achievement created in the 1970s. Some participants may have felt that the primary location for action on gender differences in participation in physics should be at the classroom level.

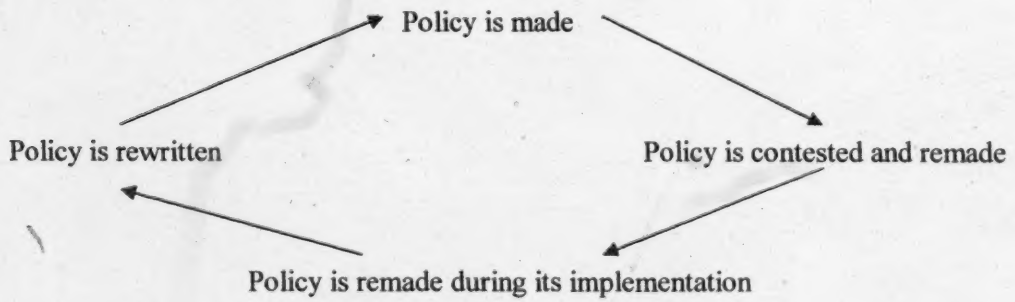
Overall a moderate amount of action related to gender differences in participation in physics took place. Most of the action was directed at resources for teachers, such as the high school science teacher manual, but some action was directly related to the *Physics 20-30 Program of Studies*. Two policy changes: an increase in the number of required high school science courses for graduation and the creation of a single integrated Science 10 course to replace the specialized grade 10 science courses also had the potential to increase participation of girls in physics courses. No evidence was found that actions were directly related to the issue of gender differences in achievement although some of the recommendations in the chapter "Teaching with a Gender Balance" in the teacher resource were supported by research on gender differences in achievement. The next chapter will look at the implications of this research particularly its implications for future science curriculum revisions in Alberta.

Implications: Equity Issues and Curriculum Revision

Implications for Future Action

The intent of this research was not to evaluate the effectiveness of the actions that were taken in increasing the participation of females in physics courses. However, data are available that indicates that no noticeable change in gender differences in participation in Physics 30 has resulted from these actions. The lack of change in female participation in Physics 30 may reflect other unidentified actions that worked against a potential increase in participation. Research described in Chapter 2 (The Background) suggests that the implementation of gender equity policies and interventions interact with many other factors at the classroom level in unpredictable and in some cases negative ways. There is also some research that evaluates interventions and curriculum changes that do seem to increase participation of females in high school physics courses. Some actions that were recommended by the Science Council of Canada and other sources were not implemented in this science curriculum revision. These sources could be used to suggest actions that could be taken in the current science revision in Alberta to increase female participation in physics courses.

Scott (2000) illustrates a model of curriculum policy creation that is circular in nature:



(Figure 2.1 Model C, p.24).

This case study might be useful to the current science curriculum revision process in Alberta. The process of reflection on the process (and in a more limited way the

outcomes with respect to gender issues) of the last science curriculum revision process might provide insight into rewriting the policy for a new *Physics 20-30 Program of Studies*.

The actions taken in the 1984-1995 science curriculum revision in Alberta may also have had some affect on female students' interest in careers in science, in female students' self-esteem and in the acceptance of females in physics classrooms and in science and engineering careers. Future research might provide insight into the effects of the actions taken in Alberta and across Canada, on factors such as these.

Reflecting on the Actions Taken–Data and Research Revisited

In Chapter 1 (Locating the Research), data was presented that indicated that there was no noticeable change in the gender difference in participation in Physics 30 as measured by students writing the Physics 30 Diploma Examinations from 1995-2000. The percentage of all students participating in Physics 30 courses also did not change noticeably over this time period. In 1995-96 the percentage of grade 12 students (as measured by the number of students enrolled in a 30-level English course) who wrote the Physics 30 diploma examination was 21.0 %. In 1999-2000 this percentage had increased slightly to 21.9 %. (Alberta Learning, 2000). SAIP (Council of Minister of Education Canada, 1999) measured participation in grade 12 science courses in Alberta as the percentage of the 16 year-old cohort that entered grade 10 who wrote diploma examinations in that subject in grade 12. Using this measure, the percentage of students who participated in Physics 30 was 7% in both 1995-96 and 1998-99. Based on this data actions taken during this science curriculum revision that were designed, at least partially, to increase participation of all students in Physics courses in Alberta and particularly of females, do not appear to have been successful.

The lack of change in female participation in Physics 30 may reflect other unidentified actions that worked against the success of actions taken to create a potential increase in participation of female students in physics courses. One example of an action that may have had the potential to increase participation of females in Physics courses is the STS emphasis taken in the curriculum revision. Research by Ramsden (1990) and Eijkelhof and Kortland (1988) found an STS-type of emphasis was successful in

increasing female students' interest in physics courses. Ramsden reported increased enrollment of female students in her study in future physics courses. However, she also found that in classes taught by physics specialists the changes were not implemented to the same extent as in non-specialists classes. For these classes, in contrast to the other classes in the study, there was no significant increase in either female students' interest in physics or future participation. She suggested that the teachers who were physics specialists did not feel the same need to change their instruction as the non-specialists and were less confident about changing their teaching practice. Many high school physics teachers in Alberta are physics specialists. Research on how they responded to the STS emphasis might help determine if a lack of implementation of the STS emphasis in Alberta negated any possible benefits to increase participation of females in this course. Instances of schools or classrooms where gender participation in physics is equal might also provide insights into the potential of an STS emphasis to increase female participation in high school physics courses.

The units developed in both the Ramsden (1990) and Eijkelhof and Kortland (1988) studies had specific teaching strategies such as cooperative group work, student involvement in independent research and connection of the STS emphasis to local contexts included within the curricula. Eijkelhof and Kortland (1986) found that the STS emphasis was more successfully implemented by teachers when it was fully integrated with physics concepts rather than suggested as in some of the units. The current STS emphasis in science courses in Alberta is physically separated as one of three parallel strands in the *Physics 20-30 Program of Studies* document: *Knowledge*, *Skills* and *STS Connections*. A more tightly integrated *Physics 20-30 Program of Studies* (concepts, skills and STS emphasis) might be effective in increasing female participation in Physics 20-30 courses. Embedding some of the teaching strategies suggested in other studies within the document might also be effective in increasing female participation. Embedding teaching strategies within program of studies documents in Alberta appears to have been avoided in the past. Teaching strategies are more likely to be suggested in teacher manuals, teacher workshops (such as those conducted during implementation of the 1995 science curricula) and approved text resources.

Hughes (1999) suggested that the STS emphasis could backfire against increasing participation of females in science if in classrooms teachers unwittingly associated an STS emphasis with females and "soft science". Recent research (Kenway and Willis, 1998) suggests that the implementation of gender equity policies and interventions interact with many other factors at the classroom level in unpredictable and in some cases negative ways. This may be another factor that limited the effectiveness of the STS emphasis on increasing female participation in physics courses. Research at the classroom level might provide insight into how the STS emphasis is perceived and presented in classrooms in Alberta particularly in high school physics classes.

Some actions that were recommended by the science council and other sources were not implemented in this science curriculum revision. The most dramatic was the lack of any female scientists mentioned by name in the *Physics 20-30 Program of Studies*. Closely associated with this action, was the omission in the *Physics 20-30 Program of Studies* to take advantage of the opportunity suggested by the Committee on Tolerance and Understanding report (1984b), to critically evaluate the nature of physics knowledge building and how historically women were prevented from participating in this process. Some of the individuals interviewed in this research suggest that since more information is available on the historical role that woman played in building physics knowledge and of the restrictions to their involvement, this information could be integrated into the physics curricula in the next revision.

Research on interventions that increased participation of females in physics courses in other countries and provinces appears to be available. Several examples were discussed in the background literature to this research. These sources could be used to suggest actions that could be taken in the current science revision in Alberta to increase female participation in physics courses. It is unfortunate that a similar review of interventions, across Canada and internationally, commissioned by the Deputy Minister of Education in 1985 (Harvey Social Research Ltd,1985b), does not appear to have been used in this science revision. This report suggested that, at the time, few evaluations of actions designed to increase gender equity were available. However, some successful interventions were reported in this document. One example was a program called Math

for Girls, where 350 girls were taught a special eight week math course by female university students majoring in mathematics. The enrollment in future mathematics and science courses for the test group was double that of students not enrolled in the program. A similar strategy might be useful in Alberta, in sciences like physics. This report is still available in the Government of Alberta library and could also be used as a source of possible interventions. A similar report could be commissioned to collect information about curriculum projects or other interventions that have been successful in increasing the participation of female students in high school physics courses elsewhere in Canada or world-wide if this is a goal of science curriculum revision in Alberta.

The success of other provinces in Canada in encouraging girls to participate in Physics was another potential source of ideas that was not fully utilized in this science revision. Haggerty (1991) reported on gender differences in participation in grade 11 and grade 12 physics courses in 1987-88 in provinces across Canada. Alberta had the second lowest percentage of female students enrolled in physics courses in grade 11 (38 %) and in grade 12 (32 %). In contrast, the neighboring province of Saskatchewan had higher percentages - 47 % in grade 11 and 44 % in grade 12. The greatest equity of enrollment was found in Francophone programs in Ontario (53 % in grade 11 and 52 % in grade 12) and New Brunswick (48 % in grade 11 and 47 % in grade 12). Investigation of physics curricula and other conditions supporting gender equity in science education in these provinces might provide evidence of strategies that would increase female participation in physics in Alberta.

There are promising changes across Canada in female participation in science-related careers. A slightly higher percentage of female students completed undergraduate university degrees in Engineering and Applied Science across Canada in 1998 (21.1 %) as compared to 1994 (18.4%). This was also true for completion of degrees in Mathematics and Physical Sciences (31.2 % in 1998 and 29.9 % in 1994). Increased enrollment in these undergraduate degrees has a potential of increasing the financial benefits for women as well. Median incomes of all students who completed undergraduate degrees in Canada in 1995, were highest five years later for students with degrees in Engineering and Applied Sciences ($56 000) and second highest for students

with degrees in Mathematics and Applied Sciences ($54 000). This same trend also existed for students who graduated in 1990 (Statistics Canada, 2003).

An increase in the percentage of female physics teachers in Alberta may be an impact of the actions taken in this curriculum revision and other actions taken during this time period. If so, these role models may affect future female participation in physics courses in Alberta. There could be a time-lag in how these actions affect female participation in courses. Participation in Mathematics 30 and Chemistry 30 courses is fairly gender neutral in Alberta and this change may be reflected in other mathematics and science courses in the future.

Interview and document evidence suggests that gender differences in achievement were not a widely discussed issue at Alberta Education during this science curriculum revision. Relatively small gender differences, primarily on large scale international tests and fairly gender neutral achievement on Provincial diploma examinations and classroom marks, may have contributed to the low priority of achievement differences as an issue. The Physics 30 diploma examination results for most years from 1990 to 2000 (presented in Figure 1) illustrate only small gender differences on this physics assessment, which may not be statistically significant. A special section of the 2000 Annual Report (Alberta Learning, 2001) titled "Performance Differences of Males and Females on Alberta Provincial Tests" contains an analysis of gender differences on the June 2000 diploma examinations. There were no statistically significant differences in the performance of males and females on this examination. In Alberta, on the large scale examination that most closely matches the Physics 30 Program of Studies, gender differences in achievement did not exist in June 2000. Discourse that took advantage of this provincial data could be used to encourage female students to enroll in physics courses in Alberta.

The current Deputy Minister of Education in Alberta has suggested that at the end of the 2003-2004 school year the written-response portion of the Mathematics and Science Diploma Examinations in Alberta will be eliminated. This could have consequences for the achievement of female students in Physics 30 in Alberta. At the same time, the 2001 Annual Report (Alberta Learning, 2002) did not contain data on participation by gender on diploma examinations for the year. Changes in participation

that might result from examination changes may not be readily scrutinized by the public if this data is not easily available. This research suggests that data on gender differences was capable of changing the perceptions of individuals about the issues and therefore the actions on equity they were willing to support. Particularly if these changes to the examinations are made, data on participation by gender in the diploma subjects should be re-instated in the Annual Report for public scrutiny.

Implications for Other Equity Issues

There are other identifiable groups for which equity of participation and achievement is an issue. Discourse on issues such as: Aboriginal students' achievement and participation in many high school courses; boys relatively low participation in high school English courses and relatively low rate of high school completion; and inequity of participation of students based on socioeconomic status are some examples. Evidence of conditions that seemed to increase the probability of action on issues in this science curriculum revision might provide insight to individuals interested in these or other equity issues.

Availability of data that can elucidate whether participation or achievement differences exist for identifiable groups is one condition that seemed to support the translation of discourse into action. In the United States disaggregating achievement data by socioeconomic status, race and gender is a common trend. Providing this data for Alberta students might help to identify where equity issues exist. Support for actions that benefit one identifiable group might be more likely if the action contributed to benefits for other identifiable groups of students. Educational research, theories and international discourse contribute to the perception that an issue is important and create the climate for action.

Curriculum Revision

In Chapter 1 (Locating the Research), I wondered why many educators felt enough had been done about gender issues in physics education in Alberta and if sufficient action had been taken to address this issue. Based on this research it appears that gender issues were discussed in Alberta during this science revision and that some

actions were taken in response to this discourse within the *Physics 20-30 Program of Studies* and related documents. However, those actions did not appear to have increased the participation of girls in high school physics classes in Alberta or to have decreased the gender difference in participation in Physics 30. Not all of the actions suggested by available documents at the time were acted on, and other actions that could be taken are suggested based on recent research. Alternatively other locations for action might be needed. In either case sustaining interest in an issue until it is resolved may be difficult for educators. Talk about action may contribute to a belief by educators that sufficient action on an issue has been taken or to a belief that change is not possible.

The process of curriculum revision in Alberta might benefit from a process for examining the outcomes of previous revisions in relationship to specific goals. In this science curriculum revision one of the goals, although not specifically stated, appeared to have been to increase participation in sciences. Increased participation of females in physics courses also appeared to be one of the goals of the revision (although this was not as clearly supported). Data collected by Alberta Education indicates that these goals were not met for Physics 30. Individuals interviewed in this research did not appear to be sure whether the revision had had an affect on participation or not. The Alberta government is currently revising their science programs. They might want to examine whether some of the goals set for the last revision were successful and examine current research to try to shed light on why or why not actions taken to meet these goals were successful. Some of the documents associated with the last science curriculum revision contain information that would be helpful in this regard.

Curriculum revision is intricately associated with implementation. The last senior high curriculum revision was reviewed in 1989 at the Minister's forum on secondary education policy implementation. In the report of this review (Alberta Education, 1990b), several criticisms of the process emerged related to insufficient support for implementation, the delay of resources for the new programs, and a large staff turnover and reduction during implementation. Annual reports include other sources of evaluation information. This research project might also be helpful as a partial review of the actions related to gender differences, taken in the Physics 20-30 Program of Studies and related

documents in the last science curriculum revision in Alberta.

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Appendix A

Document Summary Form No. 9

Document type: RefD,
Document codes: OP, SP, CP, PI, PV, CV, RCV
Date obtained: April 24, 2002

Name or description of document:

Science Education in Canada, 1987: Science for Every Student + 3 years. A report prepared for the Science Council of Canada by Orpwood Associates, May 1987.

Event or contact, if any, with which document is associated:

Large study titled: *Science for Every Student: Educating Canadians for Tomorrow's World.* Obtained from the Devonian Library subsequent to reading the original report.

Significance or importance of document:

Follow up on the implementation of specific recommendations of the report three years later across Canada. This is significant because it includes evidence of the re-discourse of the recommendations and the acknowledgement of perceived action or inaction in Alberta on those recommendations from the point of view of several curriculum branch staff members, curriculum committee members and 'involved' university curriculum representatives.

Several Alberta Education staff persons were interviewed: Mr. Garry Popowich (Associate Director of Curriculum) was the intended contact at Alberta Education. Since he was "too elusive" (Appendix B, p.34) Keith Wagner (elementary education ? title not provided), Phil Campbell (program manager high school science program), and Bernie Galbraith (program manager science - junior high) were interviewed.

Others Interviewed: Dr. Heidi Kass (Department of Secondary Education, University of Alberta) and Dr. Douglas Roberts (Head, Curriculum and Instruction, University of Calgary). Both of these individuals appear in other documents – particularly Roberts who is referenced in curriculum documents.

Brief summary of relevant contents (Quotes, connections, follow-up questions):

Interviews were conducted across Canada where "ministries of education, science teachers associations and some faculties of education and selected other individuals were contacted by letter and phone to invite comments on the impact of Report 36 and on present developments in science education in their jurisdiction" (p. 3).

The interview transcripts are organized by the 8 recommendations of the report. Respondents were asked specifically about each of the recommendations. Recommendation 2. 'Increasing the participation of young women in science education' is a specific recommendation discussed. This makes it clear that Phil Campbell (program manager high school science) was aware of this recommendation at this point in time (the interview) if not before. It had resurfaced in discourse.

In the summary of the document an important hypothesis/interpretation is reported: "The Science Council's study helped create a climate of opinion in which certain policies and practices were supported." (p.4). Two quotes from the telephone interviews are used to support this hypothesis. This hypothesis suggests that discourse in and of itself can allow change without direct influence on actions (as is the case with a government policy).

With regards to recommendation 2:

"This recommendation attracted, from the beginning, a great degree of positive support and attention." (p. 7). Was this positive support present in Alberta? There is at least some evidence that it was raised as an issue at the deputy ministers level. (Doc. 16 and 17). It is present in one curriculum support document for science (Doc. 10).

"Ministries of education have generally made reference to this in new curriculum policies." (p. 8). I have found no direct reference in curriculum policies in Alberta yet. Other provinces are specifically referenced with regard to special programs related to this recommendation. (not Alberta).

Individual telephone interviews - survey notes.

Keith Wagner (elementary) – no gender reference, curriculum not currently under review

Phil Campbell (secondary) – no mention of gender recommendation

"SCR is one of larger factors that has been taken into consideration in our re-organization" (p.34). Why Phil Campbell didn't actually refer to the recommendations – almost all other respondents did refer directly to each recommendation? Was the single statement felt to be enough? Most of the other responses were specific as to action or no action related to a recommendation.

"Alberta is about to undergo a total reorganization of science programs 7-12 – all are being developed in accordance with Doug Robert's paper which was written before the SCR (as a plenary paper for the SCR)" (p. 34). This directly acknowledges the importance of Doug Robert's as an individual in this curriculum revision. This paper is only about curriculum emphasis – it is not related to any of the other recommendations in the SCR. Does that mean that the other recommendations were not important? Or is this a case of 'random loss' in the way one document was folded into another (SCR folded into the smaller Roberts' paper)? "Recommendations Phil will write or phone with these!" (p.34). There is no record of whether any follow-up by Phil occurred.

Bernie Galbraith (junior high)

Specifically addresses gender (only one of the Alberta Education interviewees) The response was word processed and sent to Orpwood Associates.

> 1. Regarding the need to increase participation of young women in science programs:
> This concern has been addressed within the specifications for the revised program. In our analysis of causes for the inequity, we have targeted on the deficit in hands-on experience with technology materials. The revised program will place much greater emphasis on technologies. Recommended learning activities will ensure that will that students develop confidence in their abilities to pursue further learnings is this area. (p. 36) (typing errors in paper)

A similar suggestion is made in SCR with reference to early science experiences. The direct intent to try to include activities of specific benefit to girls is unique. However there is no way of knowing whether similar approaches were taken with the physics curriculum. The document would not likely directly reference these as 'girls' initiatives'. Suggests influence of SCR: "The findings and recommendations have served as a major point of reference in setting directions for program revision."(p. 37). "a readiness has been established" (p. 37).

Heidi Kass (U of A)

Direct reference to gender: "There have been initiatives in the Ministry at the curriculum organization level which will increase girls participation in Science and Math. For the High School Graduation Diploma, Math requirement is now two years (was only one), this is a potentially significant step in leaving options open to girls. Science requirements have also increased." (p. 39). The question here would be was this intentional or accidental? This conversation suggests that Heidi Kass was aware of the significance. Did she make this assessment after the fact or was the discourse part of the curriculum revision process? (Document 2, p. 3. Proposed program and graduation requirements. Describes an additional course in each of mathematics and science. This is most directly referred to in the preceding discussion by "expectations for graduation, including essential concepts, skills and positive attitudes, have been developed to ensure that the goals of secondary education are deliberately and systematically covered in compulsory courses." (p.2)) (Doc. 17 Harvey Consulting. Reported on a study that suggested that delaying choice was important to increasing girls' participation in courses like math and science).

"Ministry asked Task Force to draft a set of guidelines for fair treatment of the sexes in science – the draft has been forwarded to the Ministry now." (p. 39). This statement indicates a direct interest and desire to take action – where is this document? How did it influence the curriculum? She also describes programs for girls at the U of Alberta and seminars with teachers on careers advice for girls. "Heidi's impression is that similar things are happening in Calgary." (p. 39). This is interesting because Doug Roberts' reference to recommendation 2 is "nothing specific he can point to" (p.40).

Appendix B
Time Line of Documents and Events

1984 **Minister:** Neil Webber	1985 Nancy Betkowski	1986 Nancy Betkowski	1987 Jim Dinning
Science for Every Student: Educating Canadians for Tomorrow's World			Science for Every Student + 3: Follow- up report
Committee on Tolerance and Understanding: Final Report and Curriculum Audit Report	Promoting Tolerance, Understanding and Respect for Diversity: a Monograph for Educators		
	Intervention Programs to Meet the Needs of School-Aged Females and Factors that Affect the schooling of Males and Females:	Education for Girls: Report Prepared for the Deputy Minister's Advisory Committee on the Education of Girls	
Review of Secondary Programs	Secondary Education in Alberta: Policy statement		Proposed Directions for Senior High School Programs and Graduation Requirements
	Program Evaluation		

1988 Jim Dinning	1989 Jim Dinning	1990 Jim Dinning	1991 Halvar Johnson
	Project 2061: Science for All Americans		
	Program Equity Strategic Plan: Phase I: Development of an Operational Definition		
High School Graduate Survey			Achieving the Vision: 1991 Report (Alberta Education)
		Report on Minister's Forum on Secondary Education Policy Implementation	
	Minister's Advisory Council on Science Formed	**Senior High Science Review**	
	Department Reorganization		

1992	1993	1994	1995
Halvar Johnson	Halvar Johnson	Halvar Johnson	Halvar Johnson
Achieving the Vision: 1992 Report			
Senior High Science Teacher Resource Manual	Physics 20-30 Program of Studies (Interim)	Physics 20-30 Program of Studies (Revised 1994)	
Science 10 Field Tested	**Field Test Physics 20** **Science 10 Implemented**	**Field Test Physics 30** **Physics 20 Implemented**	**Physics 30 Implemented**

Appendix C
Interview Questions

General

1. I would like to confirm your role in science curriculum revision in Alberta from 1984 to 1995. Could you describe how you were involved during this time period – especially in any capacity that relates to the Physics 20-30 Program of Studies or research studies/data collection related to gender differences in participation or achievement in science? (This data will not be included in the thesis – it will only be used to aid me in interpretation of the questions that follow)

2. Can you recall any discussion about data or issues related to gender differences in participation or achievement in secondary science, particularly physics during this time period? What can you tell me about your recollection of the nature of this discussion?

3. Did this discussion influence the revision of the high school physics program of studies and related documents like teachers' manuals, textbooks, provincial examinations or program requirements? How?

4. Can you describe any specific actions taken or directives given to working groups in the context of science curriculum revision on gender issues?

Questions Related to Specific Documents:

Review of Secondary Programs (1984)

1. In this document there were still three different sciences (Biology10, Chemistry 10 and Physics 10) referred to for grade 10 science. The decision to create a general Science 10 course is found in the 1987 Proposed Directions for Senior High School Programs. In the discussion of this change the document reads: "a general science course for all grade 10 students provides pupils with additional time to consider program options in science and to gain a more comprehensive understanding of science." (p. 12)

Was there any discussion of any anticipated impact of this change on female participation in sciences (particularly physics)? (Was any research cited?)

Science for Every Student: Educating Canadians for Tomorrow's Word by Science Council of Canada (1984) (and related documents -1983 deliberative conference in Alberta on recommendations, 1987 follow-up of influence of recommendations on Provincial science)

1. Do you recall this document? Do you recall any discussion in the science curriculum revision context related to gender differences in achievement or participation related to this document?

2. Did this discussion influence the revision of the high school physics program of studies and related documents like teachers' manuals, textbooks, provincial examinations or program requirements? How?

3. One of the eight recommendations of the Science Council of Canada report was that "Measures should be taken by educators to ensure that girls have improved opportunities and greater encouragement to participate fully in science and technology education." (p.35).
Did this recommendation influence the curriculum revision process in any way that you are aware of?

4. Three areas were suggested as possible locations for action on this recommendation: the curriculum, teaching methods and career counseling. Under the section on curriculum several suggestions are made:
The first is "to avoid choosing examples that reflect and reinforce male stereotypes and experiences" (p. 35).
Do you recall (in the curriculum revision process) any specific attention to examples with respect to reflecting a gender balance of interests? (Why or why not?)

5. The report also suggested that "the implementation of science-technology-society emphasis in science education will likely make science more attractive to girls because it will stress human aspects" (p. 35). Was there any discussion of how the STS emphasis of the new science curricula might affect girls' interest in participation in physics (or other sciences)? (Why or why not?)

6. The last suggestion with respect to curriculum was to "provide more accounts of the work of women scientists and inventors" (p. 36). Do you recall any specific attention to include the work of women scientists and inventors in the curriculum documents for physics that might have arisen from this recommendation? (Why or why not?)

Report of the Committee on Tolerance and Understanding and associated curriculum audit report and recommendations (1984)

1. Do you recall this document? Do you recall any discussion in the science curriculum revision context related to gender differences in achievement or participation related to this document?

2. Did this discussion influence the revision of the high school physics program of studies and related documents like teachers' manuals, textbooks, provincial examinations or program requirements? How?

3. The curriculum audit report recommended that "curriculum committees should be made aware of the findings of the curriculum review and encouraged to support the tolerance criteria in current and future curriculum development and learning resource selection procedures" (p. 69).
Do you recall whether this recommendation was followed for science curriculum committees (particularly Physics 20-30) and if so how the findings were presented to curriculum committees?

4. One of the criteria (4) developed by the committee was to "convey that excellence in human endeavour may be found in different ways in all human groups" The report for

math and science made "recommendations ... to highlight the contributions of men and women and representative minorities in the curriculum documents" (p. 29). Did this have any impact on the program of studies for science and particularly Physics 20-30?

5. Another criteria (6) was to "implicitly and explicitly convey the nature and value of critical thinking in constructing our everyday interpretations of the world and the people within it". The report concluded that "critical thinking skills in mathematics, science and practical arts, for example, are not directly applied to the assessment of historical forces, propaganda or prejudice" (p. 32) – suggesting that this could be included in future Program of studies documents.
Did this have any impact on the program of studies for science and particularly Physics 20-30?

Reports to the Deputy Minister's Advisory Committee on the Education of Girls by Harvey Social Research (1985)

1. Do you recall this document? Do you recall any discussion in the science curriculum revision context related to gender differences in achievement or participation related to this document?

2. Did this discussion influence the revision of the high school physics program of studies and related documents like teachers' manuals, textbooks, provincial examinations or program requirements? How?

Program equity strategic plan: Phase I: Development of an operational definition produced for Alberta education by the Alberta Management Group (1989)

1. Do you recall this document? Do you recall any discussion in the science curriculum revision context related to gender differences in achievement or participation related to this document?

2. Did this discussion influence the revision of the high school physics program of studies and related documents like teachers' manuals, textbooks, provincial examinations or program requirements? How?

3. The discussion of intent for the operational definition includes the following:

> Although there are no explicit guarantees in the operational definition, it is clear that where groups of students with common characteristics are not fulfilling their educational objectives or attaining the Goals of Schooling, the education system is committed to bringing resources to bear to remedy the situation. (p. 38)

(Alternative quote: "This means that differences in opportunity, participation or outcome that may exist among comparable student groups are to be acknowledged as evidence of inequities in our educational system" (p. 34).)

Do you recall whether the implications of this equity operational definition influenced the curriculum revision process? In particular were gender differences in participation or achievement in high school physics discussed in terms of equity concerns?

4. The report continues with the statement: "This means that standards and methodologies to identify student groups whose achievement is below standard must be developed" (p. 39). (Alternative quote: "student scores should be equally distributed, regardless of such variables as sex, location, or socio-economic status" p. 10)
Did Alberta Education take steps to identify and measure gender differences in achievement in response to equity concerns?

What links were made to the measurement data and actions to address any equity concerns that were identified?

<u>Senior High Science Teacher Resource Manual (1992 Interim) (Alberta Education, 1992e)</u>

1. Do you recall any discussion in the science curriculum revision context related to gender differences in achievement or participation related to this document?

2. There is a chapter in the Senior High Teacher Resource Manual titled "Teaching with gender balance". Do you recall any discussion on gender issues related to this chapter in the manual?

3. How was this chapter produced – who decided to include it, how was it researched, who reviewed it and approved it?

4. There were inservice workshops for field validation teachers and video aids produced in conjunction with many of the chapters in the resource manual. Were there inservice workshops or other materials produced that were related to this chapter on 'teaching with gender balance'? (Why or why not? How was this decided? Was there any discussion?)

Appendix D
Themes Document

The Historical-Social Context – No Action Occurs in a Vacuum

Conditions that created awareness among the science curriculum team of the wider context, national and international, related to gender differences in science participation produced conditions that supported action. This includes the availability of research documents and data particularly the resources that were directly referenced as influences in the revision process.

Evidence

Wider discourse

STS emphasis: International context and the Science Council of Canada report were cited as major influences in including an STS emphasis by other researchers who investigated aspects of this Alberta science curriculum revision (Blades, 1997; Kilian-Shrum, 1996; Kull-Romanyshyn, 1993; Panwar and Hoddinott, 1995; Roscoe, 1993) This wider context was a factor that influenced the action of including an STS emphasis in the Alberta science programs of study.

Science Council of Canada report, *Science for Every Student* (1984); American Association for the Advancement of Science report, *Science for all Americans* (1989): Direct reference in the *Senior High Science Teacher Resource Manual* (Alberta Education, 1992) to the two documents: "very influential in setting the goals, objectives and structure of the program" (p.S.1-3).

Science for Every Student + 3 Years (Orpwood Associates): Authors interviewed Doug Roberts from the University of Calgary by telephone in reference to recommendations number 2, - increasing the participation of females in science courses: "nothing has moved ahead as a result of SCR, [recommendations] #2 and#3 are under consideration with program review - the question is did this happen because of SCR or did SCR crystallize what was already in the air" (p. 40). The phrase 'crystallize what was already in the air' suggests that Roberts, from his perspective, believed that a larger discourse than the Science Council Report influenced the curriculum revision process.

Science for Every Student + 3 Years (Orpwood Associates) general overview:

> The greatest amount of activity in this area [in reference to recommendation #2; increasing female participation in science] has come from the various associations of women in science in Canada. (p.8)

In Alberta, the organization Women in Scholarship, Engineering, Science and Technology or WISEST is such an organization. Individual #1 described the direct involvement of this group in an advisory capacity during the revision process. Margaret Anne Armour, who was the chair of WISEST at the time, was also described by individual #2 as involved in this wider discourse on gender issues. Individual #2 suggested that she contributed to "peoples' professional awareness" a phrase that implies the effect of the wider discourse on the individuals involved in curriculum revision. He suggested later in the interview that this professional awareness was effective in guiding actions related to creating gender neutral contexts in documents related to the Physics 20-30 revision.

Royal Commission Report on the Status of Women sponsored a study on sex-role imagery in textbooks used in Canadian schools:

> Publishers and ministries of education across the country appointed advisory groups on sexism and began to issue guidelines for doing away with stereotyping in materials and in classroom practices. (Gaskell, 1993.p. 150)

This action also occurred in Alberta in the 1984-1995 revision.

Report prepared by Harvey Social Research Ltd. (1985) for the Deputy Minister's advisory committee on the education of girls: Many of the interventions described in this document are similar to actions undertaken during the science curriculum revision. For example, one summary of in international intervention was:

> According to the 1984 U.N. report authored by Whyte, studies of textbooks and children's reading books for sex bias are the most preliminary and basic feature of programs to counter girls' disadvantage, and represent the first stage of such initiatives. (p.3).

Later in the summary for the report, this type of review was cited as an implemented action "reported by Sweden, France, Portugal, Ireland and the Canadian provinces of Alberta, Manitoba, Saskatchewan, Ontario and Nova Scotia" (p.19). Course delay,

attention to stereotyping of female occupations, and encouraging teachers to invite female science role models into classrooms are all actions taken in the Alberta science revision that are described in this document as actions taken nationally and internationally by other education authorities.

In 1988, the Canadian Teachers' Federation produced a book titled *Women and Education: The Idea Book: A resource for improving the participation and success of female students in math, science and technology.* Jennifer Smith, the author of the chapter in the Senior High Science Teacher Resource Manual on "Teaching with Gender Balance", is referenced in this document. Other references in this book are also connected to Alberta. (ex. "Women in Science – Is there a problem in Alberta?" p.18). Dr. Margaret-Ann Armour is listed as the WISEST contact for a summer research program for girls in Alberta

Research

"Teaching with Gender Balance" in the *Senior High Science Teacher Resource Manual* (Alberta Education,1992): Reinforces a link between research context and action: "by positively incorporating knowledge gained from research into classroom practice" (p. S.3P-3).

Individual #4 made reference to the impact of research documents on the curriculum revision process as something that was internalized "like osmosis". She suggested that research was very important to the work of the science committee in the statement: "[individual X] was a researcher and had that in her/his past and [individual Z] I think she/he did nothing until she/he hired me except research".

In the summary to *Science Education In Canada: Science for Every Student + 3 years* by Orpwood Associates (1987) the authors hypothesize that "The Science Council's study helped create a climate of opinion in which certain policies and practices were supported." (p. 4). The authors suggest in this sentence that there was evidence across Canada that the report had influenced the actions taken by provincial Education Ministries by influencing the opinions of those involved in science curriculum revision.

Data

Individual # 2: "I think that [the Second International Science Study] impacted [the discussion on gender issues] in one way – to suggest that gender reporting was legitimate."

Individual #3: hadn't perceived gender differences in enrollment in physics courses as an issue until Alberta participation data was presented to him that conflicted with his experiences in the classroom.

Individual #4:

> It amazed me that before I made it a focus and looked for it – all the thing that might be gender inappropriate and might not give women the same chance – that I wouldn't even have noticed until I became aware of the fact that girls weren't participating and when you became acutely aware of it and you start looking at the resources and the things that you used to do when you were teaching – I just thought – gee if I would have known this it would have been so simple to make those kinds of changes but I wasn't aware of it. So personally it was an education for me and I became very proactive in looking for those kinds of things and making sure they were addressed.

The data changes the perception and the possibility for acting on that perception for this individual.

Senior High Teacher Resource Manual, "Teaching with Gender Balance": action on gender differences in participation in science courses is urged by referring to several pieces of data. A bar graph indicating the number of students in Alberta, by gender, enrolled in Physics 30, Chemistry 30, Biology 30, Mathematics 30 and Mathematics 31 in 1989 is linked to a chart indicating the course requirement for entrance into Honours or Specialized science programs at the University of Alberta. The link between the relatively low participation of females in Physics 30 (and Mathematics 31) and female's ability to register in specific post-secondary programs is extended by a chart that indicates the percentage of first year students enrolled in undergraduate degrees related to science by gender in Alberta Universities in 1989/90. The text elaborates a connection of this data to potential income and status for female graduates: "Females opted out of the science professions to which society attaches a higher status, with accompanying higher salaries". (p. S.3P-5)

Achieving the Vision: 1991 Report and *Achieving the Vision: 1992 Report*: Parents were urged to ask schools about data on gender differences in participation in science. The implication seemed to be that they should question any differences.